

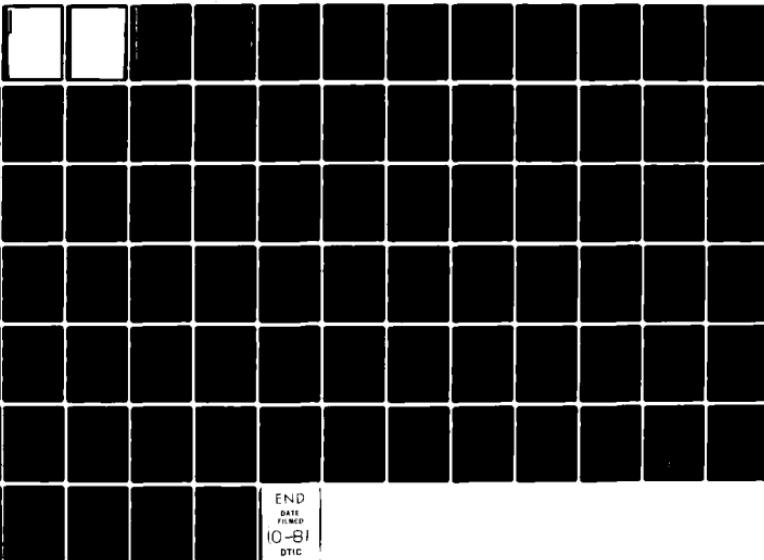
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AQUATIC HABITAT STUDIES ON THE LOWER MISSISSIPPI RIVER, RIVER M--ETC(U)
APR 81 D B MATHIS, S P COBB, L G SANDERS

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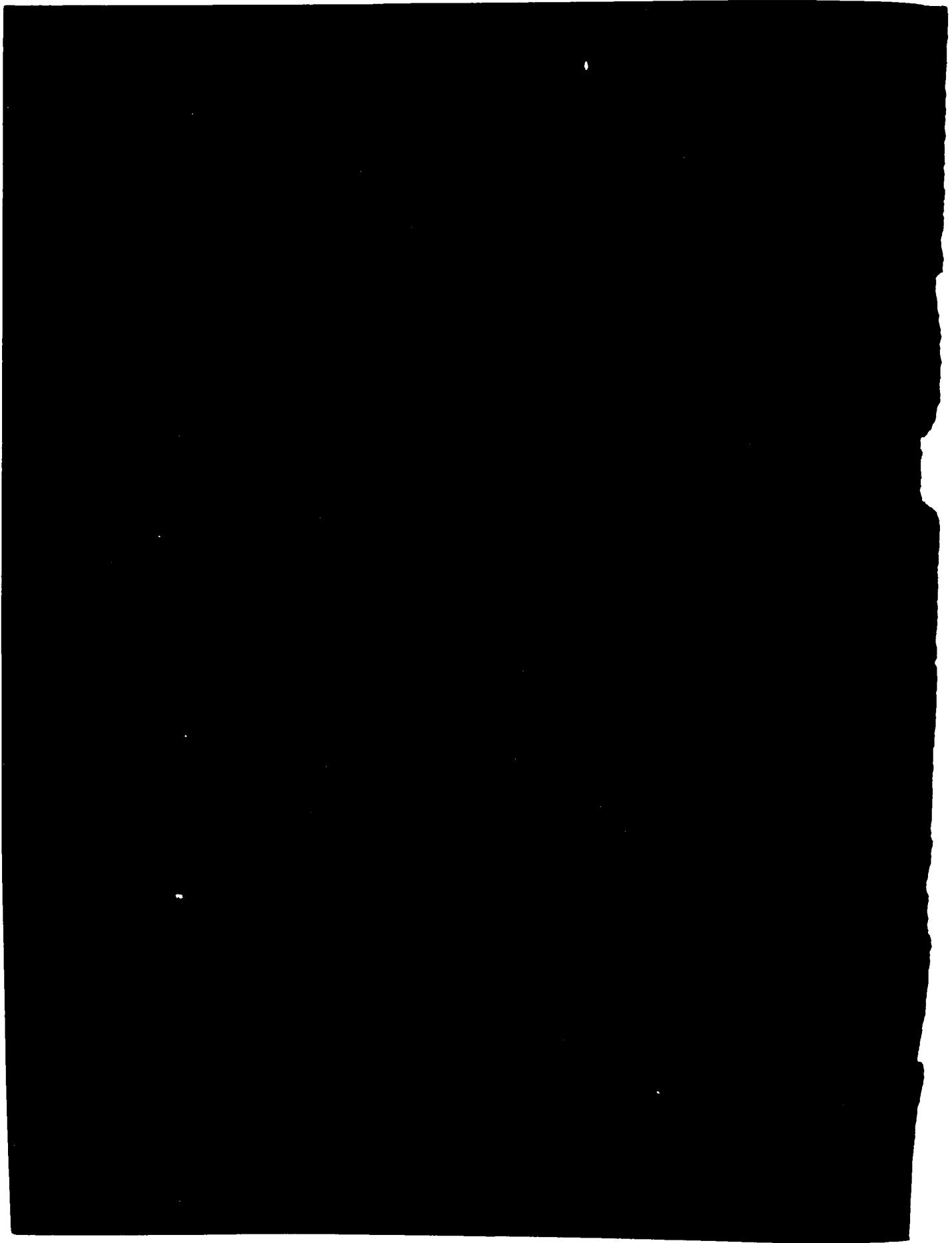
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20. ABSTRACT (Continued)

a total of 20,562 organisms, representing 72 distinct taxa, 17 orders, and 5 classes of benthic macroinvertebrates were collected.

Dike structures were the most productive habitat (563.4 organisms/rock sample). Abandoned channels were the second most productive habitat (70.04 organisms/0.05 m²). Natural banks were the next most productive habitat (9.4 organisms/0.05 m²).⁽²⁾

A complete listing of reports in the series "Aquatic Habitat Studies on the Lower Mississippi River, River Mile 480 to 530" is as follows:

- Report 1: Introduction
- Report 2: Aquatic Habitat Mapping
- Report 3: Benthic Macroinvertebrate Studies--Pilot Report
- Report 4: Diel Periodicity of Benthic Macroinvertebrate Drift
- Report 5: Fish Studies--Pilot Report
- Report 6: Larval Fish Studies--Pilot Report
- Report 7: Management of Ecological Data in Large River Ecosystems
- Report 8: Summary

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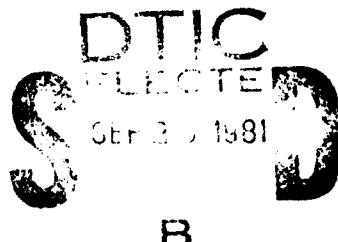
PREFACE

The work described in this report is part of the Environmental and Water Quality Operational Studies (EWQOS) conducted by the U. S. Army Engineer Waterways Experiment Station (WES), Environmental Laboratory (EL), for the Office, Chief of Engineers (OCE), U. S. Army. This is Report 3 of the series "Aquatic Habitat Studies on the Lower Mississippi River, River Mile 480 to 530." The studies were performed from April to October 1978.

This report discusses the results of an intensive pilot survey of benthic macroinvertebrate assemblages associated with each of nine major aquatic habitat types found within the leveed floodplain of the 50-mile study reach.

The report was prepared by Messrs. David B. Mathis, Stephen P. Cobb, and Larry G. Sanders, Dr. A. Dale Magoun, and Mr. C. Rex Bingham under the direction of Dr. Thomas D. Wright, Chief, Waterway Habitat and Monitoring Group, EL; Mr. Bob O. Benn, Chief, Environmental Systems Division, EL; Dr. Jerome L. Mahloch, Program Manager for EQWOS; and Dr. John Harrison, Chief, EL.

COL John L. Cannon, CE, was Commander and Director of WES during field conduct of this study. COL Nelson P. Conover, CE, was Commander and Director of WES during preparation of this report. Mr. Fred R. Brown was Technical Director of WES.



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CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI)
UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
cubic feet per second	0.02831685	cubic metres per second
feet	0.3048	metres
feet per second	0.3048	metres
miles (U. S. statute)	1.609344	kilometres
pounds (mass)	0.4535924	kilograms

AQUATIC HABITAT STUDIES ON THE LOWER MISSISSIPPI RIVER,
RIVER MILE 480 TO 530

BENTHIC MACROINVERTEBRATE STUDIES--PILOT REPORT

PART I: INTRODUCTION

Background

1. The increasing number of dike and revetment structures within many U. S. inland waterway systems is indicative of the relative efficiency and cost-effectiveness of these engineering features for aligning and stabilizing inland waterway navigation channels. However, the lack of sufficient quantitative information and methodologies to assess the impacts of these structures on waterway ecosystems has resulted in increased litigation, project delays, escalated costs, and adverse public reaction (Keeley et al. 1976).

2. Adequate assessment of the ecological impacts imposed by these structures on waterway systems requires the development of a sound data base. This data base can be used as a basis for developing environmentally compatible structure design and construction alternatives.

3. The U. S. Army Engineer Waterways Experiment Station (WES) is conducting a field investigation within a 50-mile* reach of the Lower Mississippi River between Greenville, Mississippi, and Lake Providence, Louisiana. The objectives of the study are to assess the relative ecological importance of dike and revetment structures to the riverine ecosystem in terms of aquatic habitat values and to provide guidelines for designing and modifying these structures to meet environmental quality objectives.

* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 3.

4. The dike and revetment study uses a habitat concept wherein the river reach under investigation is subdivided into its major aquatic habitat types and characterized as to both biotic and abiotic variables. In this concept, dike fields and revetted banks, although man-made, are treated as habitats exactly as other distinct biological habitats, e.g., the main channel, natural banks, sandbars, point bar cutoffs, and abandoned river channels. The ecological importance of each aquatic habitat is evaluated according to its basic water quality, production of benthic organisms, and use as spawning, nursery, and feeding areas for fishes. The function and relative value of dike fields and revetted banks as aquatic habitats within the river ecosystem are then defined using this information. Because of river dynamics, the habitat evaluation must be related to various river stages and seasons of the year.

5. To date, few ecological investigations of either a quantitative or qualitative nature have been undertaken within large river systems such as the Lower Mississippi River. The extremely dynamic physical nature of these systems and the corresponding problems encountered in attempting to obtain adequate ecological data have made such studies difficult. Many conventional aquatic sampling techniques and methodologies are either inappropriate for sampling purposes within these systems or are untested. Thus, to effectively apply the aquatic habitat concept within the study area, an essential first step was developing or testing appropriate aquatic sampling techniques for study purposes and generating sufficient baseline data to develop a sound experimental sampling design.

Purpose and Scope of Benthic Macroinvertebrate Study

6. During the period 1 April 1978 to 1 October 1978, a series of pilot surveys were conducted to develop and test sampling equipment and techniques, to select representative aquatic habitats for study, and to develop field experimental designs for intensive habitat comparisons and detailed ecological studies.

7. This report discusses the results of a pilot study of benthic

macroinvertebrate assemblages associated with the 50-mile study area. Sampling efforts were undertaken during the period 19-27 June 1978. The primary objectives of this study were:

- a. To describe and evaluate benthic macroinvertebrate assemblages associated with selected habitat types in terms of assemblage composition and structure.
- b. To provide baseline data for the selection of representative aquatic areas of each major habitat type for longer term comparative study.
- c. To gain insight into habitat data variations for future experimental sampling design considerations.

PART II: DESCRIPTION OF STUDY AREA

8. The study area encompasses a 50-mile reach of the Lower Mississippi River between Lake Providence, Louisiana, and Greenville, Mississippi (river miles 480 to 530 AHP*). This includes the main stem of the river as well as all additional bodies of water (aquatic habitats) between the main-line levees (Figure 1).

9. The Lower Mississippi River is classified as an alluvial river with a drainage system in a stage of maturity with meanders and oxbow lakes (Gulf South Research Institute 1973). The entire study reach is confined on both sides by main-line levees constructed by the Corps of Engineers (CE) for flood control purposes. Leveed floodplain width ranges from about 2 to 6 miles. The backwater areas between the levees and the Mississippi River Channel have indirect or seasonal connections with the river and are submerged during floods. No tributaries directly enter the river within the study reach.

10. The average discharge of the Mississippi River at Vicksburg, Mississippi,** is about 561,000 cfs (Mississippi River Commission 1977). Recorded discharges have ranged from about 100,000 cfs at extreme low river stage to 2,700,000 cfs at high stages, with a stage differential of 60 ft in water surface elevation at Vicksburg between extreme low and high water stages. The average water velocity within the main channel is between 3 to 6 ft/sec with a maximum recorded velocity of 15 ft/sec during extreme high riverflows (Mississippi River Commission 1977). The estimated average bed load transport at Vicksburg is 1 million yd^3/day . The average hydrograph for the river at Vicksburg shows highest discharge occurring from February through March and lowest discharge occurring from July through October. River stages recorded at the Vicksburg gaging station for the 19-27 June 1978 sampling period are tabulated below:

* Above Head of Passes.

** A major gaging and data collection point for the Lower Mississippi River, located 65 miles downstream from the study area.

<u>Date</u>	<u>River Stage, ft</u>	<u>Date</u>	<u>River Stage, ft</u>
19 June	19.4	24 June	16.0
20 June	18.8	25 June	15.6
21 June	18.0	26 June	15.6
22 June	17.3	27 June	15.8
23 June	16.6		

11. The climate of the study area is subtropically humid with a short cold season and a relatively long warm season. The predominant air mass is maritime tropical and originates over the Gulf of Mexico. Based on meteorological data obtained at Vicksburg, Mississippi, mean monthly temperatures range from about 28°C in July and August to 9.4°C in January. Record maximum and minimum temperatures at Vicksburg are 40°C in September 1925 and -18°C in February 1899. Precipitation occurs mainly as rain with annual snowfall normally averaging about 3.8 cm. Precipitation reaches a maximum in March with a monthly average of about 14.5 cm and a minimum in October when the monthly average is about 5.1 cm. Relative humidity is generally high throughout the year, averaging about 75 percent. Heavy fog occurs frequently in the area and may be expected on an average of 32 days annually (Gulf South Research Institute 1978).

12. Navigation and flood control efforts within the study reach are directed by the CE and are included in the Mississippi River and Tributaries (MR&T) Project (Mississippi River Commission 1977). This project was authorized by the U. S. Congress in 1929 to provide for flood control in the alluvial valley and for navigation improvement on the Lower Mississippi River. The four major features of the MR&T Project are: (a) levees to confine floodwaters; (b) floodways to direct excess water from the main channel; (c) channel improvements, such as artificial cutoffs and dikes and revetment, to increase the flood-carrying capacity of the river, protect levees and other structures, prevent the loss of irreplaceable lands, and improve channel alignment and depth of the river for navigation; and (d) tributary basin improvement.

PART III: TESTING METHODS

Aquatic Habitats Sampled

13. For benthic macroinvertebrate sampling purposes, nine aquatic habitat types within the leveed 50-mile study area were identified. These included dike field, dike structure, revetted bank, natural bank, abandoned channels, permanent secondary channel, temporary secondary channel, main channel, and sandbar habitats. The inundated floodplain habitat, discussed in other reports in this series, was not sampled for benthic macroinvertebrates.

14. Definitions and descriptions of the characteristics used to delineate each habitat and the percentage composition of each of total available aquatic habitats within the study area during sampling efforts are presented in Table 1. For a more thorough description of these habitats, the reader is referred to Reports 1 and 2 of this series.

Collection Techniques

15. Within the study area, available substrates for benthic macroinvertebrates range from unconsolidated silts and clays within off-channel habitats, to highly cohesive clays associated with natural bank habitats, to coarse sand and gravel substrates within the main channel, to quarry-run limestone rock associated with the dike structure habitats. This extreme diversity of substrate types precluded the standardization of sampling techniques over all study area habitats.

16. In the study, a Ponar grab sampler (0.05-m^2 surface area) was used to collect benthic macroinvertebrate samples from study areas where mud, fine sand, and medium sand substrates were encountered. These included abandoned channel habitats and other off-channel sampling stations with slack to moderate current regimes and mud, fine sand, and medium sand substrates.

17. The Ponar grab sampler, however, is often unsuitable for obtaining adequate grab samples from coarse sand and gravel substrates

normally encountered within the main and secondary channels and from the highly cohesive clay substrates encountered primarily within the natural bank habitats. A Shipek grab sampler (0.04-m^2 surface area) was found to be the best sampling device for the latter substrates. Its spring-assisted jaw closing action and heavy weight (~8 kg) make it a most efficient macroinvertebrate sampler (considering sampling vessel size restrictions) for high energy environments and coarse sand-gravel and cohesive clay substrates encountered within the study area.

18. Since the mid-1960's, quarry-run limestone rock has been used for the construction of all dike structures within the study area. Stone-size specifications used for all study area CE dike construction contracts are tabulated below:

Stone Weight		Cumulative Percent Finer by Weight
lb	kg	
5000	2268	100
2500	1134	70-100
500	227	40-65
100	45	20-45
5	2	0-15
1	0.5	0-5

19. Because of the nature of dikes and because this was a survey-oriented investigation, sampling of dike structures was done by collecting macroinvertebrate organisms by hand from individual stones from selected dikes within the dike field habitats (Figure 1). These data were then used to compile a systematic list of aquatic macroinvertebrates associated with the dike structures.

Field Sampling Design

20. Twenty-three sites were selected for sampling purposes, each representing one of the nine major aquatic habitat types identified within the study area (Figure 1). Where possible, several sites of each habitat type were included to obtain data on within-habitat data

variations and for the selection of representative sampling sites for future sampling efforts.

21. A transect sampling scheme was used within each habitat sampled. In habitats where surveyed benchmarks were available for permanent reference, such as in most dike fields, revetted and natural banks, and the main channel, a microwave positioning system (± 3 -m accuracy) was used for transect positioning. In all other habitats (most backwater areas), transects were established at roughly equidistant intervals along and perpendicular to the length of the habitat. Sampling locations for each habitat are depicted in Figures 2-12 and are discussed in the following paragraphs.

Dike fields

22. Four dike fields were sampled during this effort. These included Lower Cracraft (Figure 4), Leota (Figure 5), Island 86 (Figure 9), and Seven Oaks (Figure 10).

23. Transects (perpendicular to shore) were established 200 ft on both sides of and parallel to each dike structure within each dike field sampled; an additional transect was located midway between each dike and at 2500-ft intervals within the pool downstream of the last dike within each dike field (Figures 4, 5, 9, and 10). Three to five stations were established on each transect, the number depending on the width of each dike pool sampled. A microwave positioning system was used to establish all transect locations. Because of the diversity of sediment types encountered within these dike fields, both the Shipek and Ponar grab samplers were used (depending on sediment type) to characterize the associated benthic macroinvertebrate assemblages. Two replicate grab samples were obtained at each established transect station.

Dike structures

24. Because of potentially unique aquatic habitat or substrate for benthic macroinvertebrates created by rock dike construction, these structures were treated as a separate aquatic habitat for sampling purposes.

25. Stone substrate from each dike structure within Leota (Figure 5), Lower Cracraft (Figure 4), and Seven Oaks (Figure 10) Dike

Fields was sampled by hand to obtain a benthic macroinvertebrate taxa list from this habitat. Additionally, 20 individual rock samples (~40 lb individual weight) were obtained from the second dike within Seven Oaks Dike Field (Figure 10) to provide data on relative abundance of the dike-associated benthic macroinvertebrate assemblages. These data were reported as numbers per individual rock sample.

Revetted banks

26. Five aquatic habitats classified as revetted bank habitats were sampled. These included Mayersville Revetment (Figure 2), Worthington Revetment (Figure 5), Walnut Point-Kentucky Bend Revetment (Figures 8 and 9), and Lakeport and Sunnyside Revetments (Figure 11).

27. Macroinvertebrate sampling transects were established at 2500-ft intervals along each revetted bank, except at Mayersville Revetted Bank where transects were spaced at 1000-ft intervals (Figure 2). Microwave positioning was used to locate all sampling transects within each revetted bank habitat sampled. At each transect, six replicate macroinvertebrate grab samples were obtained with a Shipek grab sampler--three samples at a shallow depth (~3 m) and three at a depth of 9 to 12 m. Fewer samples were obtained at a transect if no sediment was obtained in the initial samples.

Natural banks

28. Five natural bank habitats were sampled. These included Island 88 Natural Bank (Figure 8), Anconia and Lakeport Natural Banks (Figure 11), Mayersville Natural Bank (Figure 2), and Seven Oaks Natural Bank (Figure 10).

29. Macroinvertebrate sampling transects were established at 2500-ft intervals along each natural bank habitats except at Anconia Natural Bank where sampling transects were spaced at 2000-ft intervals (Figure 11) and at Mayersville Natural Bank where sampling transects were spaced at 1000-ft intervals (Figure 2). A microwave positioning system was used for locating each sampling transect. At each transect, six replicate macroinvertebrate samples were obtained with a Shipek grab sampler--three at a shallow depth (~3 m) and three at a depth of 9 to 12 m.

Abandoned channels

30. Five abandoned channel habitats were sampled. These included Matthews Bend (Figure 6), Carolina Chute (Figure 3), Moon Chute (Figure 7), and Lake Port and Lake Lee (Figure 11). Matthews Bend was the only one of the abandoned channels that was confluent with the river during this sampling effort, and Lake Lee was the only one of the abandoned channels classified as a true oxbow lake.

31. Four macroinvertebrate sampling transects were established within Lake Lee for sampling purposes (Figure 11). Four sampling stations were established along each sampling transect. Two replicate grab samples were obtained at each sampling station with a Ponar grab sampler.

32. Within the four remaining abandoned channel sites, macroinvertebrate samples were obtained along three approximately equally spaced transects; three sampling stations (one near each shore and one in midchannel) were established on each transect. Two replicate samples were obtained at each transect station with a Ponar grab sampler.

Permanent secondary channel

33. American Cutoff is the only permanent secondary channel habitat within the study area. This habitat is the channel to the east and north of Lakeport Towhead (Figure 11).

34. Three approximately equally spaced sampling transects were established within this site; two sampling stations were established on each transect. Two replicate grab samples were obtained at each station with a Shipek grab sampler.

Temporary secondary channel

35. Kentucky Bend Chute is the only habitat of this type within the study area (Figure 8). This site is north of Kentucky Bend Bar at river mile 515 to 519.

36. Two sampling transects were established within this habitat for sampling purposes (Figure 8). Three stations (left bank, right bank, midchannel) were sampled on each transect. At each transect station two replicate grab samples were obtained with a Shipek grab sampler.

Main channel

37. Three transects consisting of three stations each (one near

each side of the channel and one in midchannel) were established for sampling purposes within the main channel. The transects were located at river mile 511.4 (Figure 5), 519.1 (Figure 8), and 530.5 (Figure 12). Two replicate macroinvertebrate grab samples were obtained at each transect station with a Shipek grab sampler.

Sandbars

38. Kentucky Bend Bar was the only sandbar habitat sampled (Figure 8). Two transects consisting of two stations each were established for sampling purposes. Two replicate macroinvertebrate grab samples were obtained at each transect station with a Shipek grab sampler.

Concomitant Field Data

39. For possible aid in benthic data interpretations and analyses, selected water quality and physical data were obtained concomitant with the benthic data. Surface measurements of pH, dissolved oxygen (D.O.), temperature, and conductivity were obtained at each station within each of the 23 aquatic sites sampled with an in situ (Hydrolab) water quality probe system. Surface, middepth, and near-bottom readings were taken at selected stations within each aquatic site sampled. Water depths at each station were obtained with a Raytheon strip chart recording Fathometer. A visual classification was made of the substrate type obtained at each sampling station and recorded. The visual classification was standardized to include the following general substrate types: mud (unconsolidated or loosely consolidated silt-clay); hard clay (consolidated, highly cohesive, predominantly clay substrate); hard clay and gravel; coarse sand; medium sand; fine sand; and coarse sand and gravel.

Sample Processing

40. All macroinvertebrate samples were sieved in the field using sieve buckets with No. 30 mesh screen (0.6 mm). This mesh size was also used on the top screens of the Ponar grab sampler. Each macroinvertebrate sample was then preserved in 10-percent buffered formalin.

41. In the laboratory, each sample was handpicked under 3X magnification, sorted by major taxonomic groupings, and transferred to 70-percent ethanol. A minimum of five days prior to identification, oligochaetes were transferred to a lactophenol clearing solution to aid in specific taxonomic identifications. All specimens were identified to the lowest possible taxonomic level. All grab sample data were standardized to number per 0.05 m^2 prior to data analyses.

PART IV: RESULTS AND DISCUSSION

42. Results and discussion of data are presented below by habitat type. The main channel, sandbar, and secondary channel habitats were grouped under the general heading "other aquatic habitats" for discussion purposes because of the similarity in physical and biological characteristics of each habitat during sampling. Additionally, a summary and comparison of data across habitats is included at the end of this Part.

Dike Fields

Results

43. From the four dike field sites, 220 grab samples were obtained: the number obtained from each site depending on the length of the site, the number of dikes present, and the width of the individual dike pools sampled. Sediments were variable within each dike field sampled and ranged from unconsolidated mud to highly cohesive clay to coarse sand and gravel. Coarse sand and gravel was by far the predominant substrate type encountered within each dike field.

44. Overall, 1623 organisms representing 32 distinct taxa, 11 orders, and 4 classes of benthic macroinvertebrates were collected (Table 2). Immature insects collected included 11 genera of Diptera, 5 genera of Ephemeroptera, 2 genera of Hemiptera, and 1 genus each of Odonata, Trichoptera, Lepidoptera, and Coleoptera. Oligochaeta collected included 3 genera of Plesiopora and 1 genus of Prosopora. Also collected were 2 genera of pelecypod Molluscs and one genus of Amphipoda.

45. The average macroinvertebrate sample density for the four dike fields was $7.4 \text{ organisms}/0.05 \text{ m}^2$. Average number of taxa collected was $0.9/0.05 \text{ m}^2$.

46. Lower Cracraft Dike Field. Moderate current velocities and high water turbulence were noted over the length of this site. The water column was well mixed with little vertical variation in the water quality variables measured (Table 3). Sediments within this site varied from hard clay banks, to unconsolidated silt-clay and silt-clay/fine

sand mixtures found along the bank downstream of the dikes 1 and 2 and in the shoreward portion of the pool, to extensive deposits of medium to coarse sand in the central pool areas of the dike field. The bank is revetted from the upstream end of the dike field to about midway downstream in the pool below dike 3 (Figure 4). This revetment is overlain with silt-clay and fine sand sediments. Gravel mixed with coarse sands was present in the plunge pools below dikes 1 and 2. Water depths at the ambient river stage of 17 ft were about 40 ft in the plunge pools directly downstream of the dikes and in the central and near-bank pool areas. Depth diminished toward the shoreline of the sandbar.

47. Seventy macroinvertebrate grab samples were obtained from this site. Twenty-three distinct taxa were represented in the 1165 organisms collected (Table 2). The average sample density was 16.6 organisms/ 0.05 m^2 ; the average number of taxa collected was 1.5/ 0.05 m^2 . The oligochaete Limnodrilus spp. was the most abundant taxon collected, representing 96 percent of the total sample density. This genus was represented by L. cervix, L. hoffmeisteri, L. profundicola, and numerous L. immatures

48. Samples obtained from the mud and mud and fine sand substrates found in the part of the pool adjacent to the bank between dikes 1 and 2 (stations 4, 7, 11, and 12) contained over 80 percent of the total macroinvertebrate sample density from this site. Sample densities from these stations ranged from 70 organisms/ 0.05m^2 at station 11 to 114 organisms/ 0.05 m^2 at station 7. The coarse sand and gravel sediments, which were distributed over most of the dike field, contained very few organisms.

49. Seven macroinvertebrate taxa were collected at this site that were not obtained at the other dike fields. These included the oligochaetes Lumbriculidae sp., Limnodrilus profundicola, and Dero sp., the chironomids Glyptotendipes meridionalis and Chironomus sp., the mayfly Hexagenia limbata, and the hemipteran Mesovelia sp.

50. Island 86 Dike Field. The average water surface temperature for this site was 27.5°C . The average surface D.O. reading was 7.5 mg/l with a maximum recorded surface reading of 9.6 mg/l . Additional water

quality data for this site are presented in Table 3. Shallow water depths (1 to 1.5 m) were recorded at all stations and current velocities were moderate relative to main channel conditions. Medium to coarse sand was observed at all stations except station 10 where a layer of fine sand and mud had been deposited over the underlying coarser sand substrate.

51. Twenty-eight grab samples were obtained from this site (Figure 9). Twenty-six organisms, representing 7 distinct taxa, were collected. The average sample density was 0.86 organisms/0.05 m²; the average number of taxa collected was 0.57/0.05 m² (Table 2).

52. Taxa collected included the dipteran larvae Procladius subletti, Palpomyia sp., and Rheotanytarsus sp., the oligochaetes Limnodrilus cervix and L. hoffmeisteri, the mayfly Pentagenia vittigera, and the pelecypod Corbicula fluminea (Table 2).

53. Seven of the 15 stations sampled contained no organisms. Both the average density and the number of taxa were highest at station 10, which was located adjacent to the bank downstream from the first dike. This station was the only one characterized by fine-grained sediments.

54. Seven Oaks Dike Field. The average water surface temperature for this site was 27.8°C. The average surface D.O. reading was 7.5 mg/l with a maximum reading of 9.7 mg/l. Additional water quality data for this site are presented in Table 3. Sand-size sediments were predominant throughout most of the dike field. Fine sand and silt/clay mixtures occurred along the bank between dikes 1, 2, and 3 and at station 8 in the pool downstream from dike 5 (Figure 10). Current velocities ranged from slack at the bank stations to moderate at most remaining stations.

55. Sixty-eight macroinvertebrate grab samples were obtained from this site (Figure 10). Organisms collected totaled 260, representing 18 distinct taxa (Table 2). The average sample density was 3.8 organisms/0.05 m²; average number of taxa was 1.0/0.05 m². The burrowing mayfly Tortopus incertus was the most abundant taxon collected, representing

52 percent of the total sample density. The oligochaete Limnodrilus spp. was the second most abundant taxon collected, representing 24.2 percent of the total sample density. This genus was represented by the species L. cervix, L. hoffmeisteri, L. udekemianus, and numerous L. immatures. Next in order of abundance were the mayfly Pentagenia vittigera (6.5 percent), the pelecypod Corbicula fluminea (6.5 percent), the midges Cryptochironomus sp. (4.2 percent) and Coelotanypus scapularis (1.2 percent), and the caddis flies Hydropsyche spp. (1.2 percent). The oligochaete Limnodrilus udekemianus and the sprawling mayfly Stenonema integrum occurred at Seven Oaks and were not obtained in grab samples from the other dike field sites.

56. Leota Dike Field. The average water surface temperature for this site was 26.7°C. The average surface D.O. reading was 7.2 mg/l with a maximum recorded reading of 11.0 mg/l. Additional water quality data for this site are presented in Table 3. Current velocities were moderate to slack at all sampling stations. Bottom sediments were predominantly medium to coarse sands and coarse sand and gravel, except at stations 1, 2, and 22 (Figure 5). Stations 1 and 2, located 200 ft upstream from dike 1, were characterized by mud and fine sand-size sediments. Station 22, located 200 ft downstream from dike 3, was characterized by hard clay sediments.

57. Fifty-four macroinvertebrate grab samples were obtained from this site. From this effort, 172 organisms, representing 12 distinct taxa, were collected (Table 2). The average sample density was 3.2 organisms/0.05 m²; the average number of taxa collected was 0.6 taxa/0.05 m². The burrowing mayfly Tortopus incertus was the most abundant taxon collected, representing 71 percent of the total sample density. Next in order of total abundance were the dipteran Chaoborus punctipennis (9.9 percent), the amphipod Gammarus sp. (7.6 percent), the oligochaete Limnodrilus spp. (5.8 percent), the chironomid Polypedilum sp. (1.2 percent), and the pelecypod Corbicula fluminea (1.2 percent). The chironomids Polypedilum sp. and Xenochironomus sp. and an aquatic moth (Lepidoptera) occurred at Leota and were not obtained in grab samples from the other dike field sites.

58. Macroinvertebrate densities were uniformly low throughout this site; fifteen of the 27 stations sampled contained no organisms. Forty-seven percent of the total sample density occurred at bank station 22, which was characterized by a hard clay substrate. The burrowing mayfly Tortopus incertus accounted for 99 percent of the total sample density at this station.

Discussion

59. The dike field benthic macroinvertebrate assemblage was characterized in June 1978 by a diverse variety of both lotic- and lentic-adapted taxa. The oligochaete Limnodrilus spp. was numerically the most abundant taxon collected, representing 74 percent of the total dike field organisms (Table 2). This genus was collected in 26 percent of the total grab samples obtained from the four dike field sites (primarily from fine-grained substrates) and was represented by the species L. cervix, L. hoffmeisteri, L. udekemianus, L. profundicola, and numerous L. immatures. Limnodrilus spp. ranged in abundance from a minimum of 5.8 percent of the total sample density within Leota Dike Field to a maximum of 96 percent of total sample density within Lower Cracraft Dike Field. The genus was the most abundant taxon collected from both the Lower Cracraft and Island 86 Dike Fields.

60. The burrowing mayfly Tortopus incertus was numerically the second most abundant taxon collected, representing 16.1 percent of the total dike field sample density. This species ranged in abundance from a minimum of 0 percent of the total sample density within Island 86 Dike Field to a maximum of 71 percent of the total sample density within Leota Dike Field. It was the most abundant taxon collected in both Leota and Seven Oaks Dike Fields. Although this taxon accounted for a significant percentage of the total dike field sample density, it was only collected in 8 percent of the 220 grab samples obtained from the four dike field sites. Its presence was restricted primarily to small reaches of natural bank habitat found in several of the dike fields and to the microdepositional zones between successive dikes, which were composed of relatively firm mud substrates.

61. The burrowing mayfly Pentagenia vittigera and the pelycypod

Corbicula fluminea were the only remaining taxa that were frequently collected from the four dike field sites, but characteristically at low levels of abundance. Each was collected from all four sites. P. vittigera accounted for 1.6 percent of the total dike field sample density and was collected almost exclusively from natural bank clay substrates. C. fluminea accounted for 1.5 percent of the total dike field sample density and was collected in 10 percent of the 220 dike field grab samples obtained. C. fluminea had its greatest frequency of occurrence within Seven Oaks Dike Field where it was collected in 21 percent of the 68 grab samples obtained. It was one of the few taxa that was frequently collected at sampling stations with coarse sand and gravel substrates.

62. The overall average sample density of macroinvertebrates collected from the four dike field sites was 7.4 organisms/0.05 m², and ranged from a minimum of 0.9 organisms/0.05 m² within Island 86 Dike Field to a maximum of 16.6 organisms/0.05 m² within Lower Cracraft Dike Field (Table 2).

63. Thirty-two distinct taxa were collected from the four dike field habitats. The number of distinct taxa collected from each dike field ranged from a minimum of 7 total taxa collected from Island 86 Dike Field to a maximum of 23 total taxa collected from Lower Cracraft Dike Field. The average overall number of taxa collected per sample was 0.9 taxa/0.05 m² and ranged from a minimum of 0.6 taxa/0.05 m² within both Island 86 and Leota Dike Fields to a maximum of 1.5 taxa/0.05 m² within Lower Cracraft Dike Field (Table 2).

64. The four dike field sites varied noticeably with respect to macroinvertebrate assemblage composition and structure. This variance is attributed in large part to differences in the diversity and type of bottom sediments encountered within each dike field. These differences are a function of both physical habitat conditions that existed within each site prior to dike construction and site-specific responses to changing river stage conditions.

65. The majority of organisms collected from the four dike field sites were obtained either from small reaches of clay bank substrate or

from sampling stations located within microdepositional zones created by eddy action and which were characterized by silt/clay substrates. Although the predominant substrate from each of the four dike field was coarse sand and gravel, these sediments contained few or no macroinvertebrate organisms.

66. The mixed lotic- and lentic-adapted composition of the taxa collected from these dike fields indicates that their origin is primarily from main channel drift and that a characteristically distinct macrofaunal assemblage did not occur within this aquatic habitat under the river conditions sampled. However, the high number of distinct macroinvertebrate taxa (32) collected from these sites (second only to the abandoned channel habitats with 39 distinct taxa) indicates that these dike fields are effective collectors of macroinvertebrate drift. Additionally, because of the abundance of lentic-adapted taxa in these samples, certain of these dike fields may also serve as effective extensions of the abandoned channel during low flow and dike pool formation when the majority of the abandoned channels are totally isolated from the main channel ecosystem.

Sampling considerations

67. Because this investigation was survey-oriented, a systematic transect sampling scheme, using predetermined transect locations, was used within each dike field site. Variance component analysis for the average total density and number of taxa collected per sample was used to assess the adequacy of this sampling scheme and for input into future experimental design considerations. The total dike field habitat sample variance was partitioned into the following additive variance components: (a) variance among replicates within stations and sites, (b) variance among stations within sites, and (c) variance among sites (Table 4).

68. For the total density, the results indicated that the variance among sites component explained only 5.13 percent of the total variance. The remainder, or 94.87 percent, of the total variance was attributable to the variance among replicates within stations and sites and the variance among stations within sites. The majority of this

(67.88 percent) was attributable to the variance among stations within sites component. This high sampling variance is attributable in large part to the extremely patchy sediment distributions encountered within these dike field sites during the sampling effort.

69. The results of the variance component analysis for the number of taxa per sample yielded somewhat different results. As with the total density parameter, the variance among sites component was fairly low (7.53 percent). However, the remainder of the total variance was about equally divided between the variance among stations within sites and the variance among replicates within stations and sites components. Within this habitat, spatial variation in the number of taxa collected is evidently as great on a small scale (replicated subsample) as it is over stations within each dike field sampled.

70. This analysis of variance (ANOVA) procedure indicates that for quantitative field comparisons of dike fields, a stratified random sampling scheme appears to be a desirable field experimental design approach. This is supported by the large observed variance for total density estimates attributable to the variance among stations within sites component, due in large part to extremely patchy sediment distributions. In order to develop an effective stratified sampling design, a field reconnaissance of sediment types within each dike field should be conducted prior to each sampling effort undertaken (i.e., as a function of river stages, season, etc.). This sediment reconnaissance is necessitated due to the anticipated significant changes in sediment distribution patterns as a function of river stage.

71. Replicated subsampling also appears to be a desirable sampling consideration, particularly if the ANOV approach is to be used for data analysis. This additional effort will be required to effectively partition out the within station sampling variance component (which otherwise is additive at the replicated sampling station level) to provide for more adequate hypothesis testing.

Dike Structures

Results

72. Current velocities varied considerably around each dike sampled but were generally characterized as moderate to approaching main channel conditions. Water turbulence was extremely high around each dike sampled.

73. Organisms collected from the 20 individual rock samples totaled 10,726, representing 18 distinct taxa, 9 orders, and 3 classes of benthic macroinvertebrates (Table 5). An additional 10 taxa, 4 orders, and 1 class of benthic macroinvertebrates were collected from the general survey of study area dike structures (Table 6).

74. Immature insects collected included 6 genera of Diptera, 4 genera each of Ephemeroptera and Trichoptera, 3 genera of Odonata, and 1 genus each of Plecoptera, Lepidoptera, and Collembola. Mollusca collected included 2 genera of Gastropoda and 1 genus of Pelycypoda. Three genera of Crustacea were collected (one genus each of Isopoda, Amphipoda, and Decapoda) as well as the free-living leeches Hirudinea.

75. From the 20 individual rock samples, the net-spinning caddisflies Hydropsyche spp. was by far the most abundant taxon collected, representing 86.4 percent of the total sample density (Table 6). The tube-building dipteran larvae Rheotanytarsus sp. and Polypedilum sp. were the next most abundant taxa collected, representing 5.1 percent and 4.2 percent of the total sample density, respectively.

76. The net-spinning caddisfly Potamyia flava and the clinging mayflies Baetis sp., Stenonema integrum, and Heptagenia marginalis were frequently collected from the individual stone samples and characteristically at low levels of abundance.

77. The average total density of benthic macroinvertebrates collected from the 20 substrate samples was 536.4 organisms/rock sample. Taxa averaged 7.3/rock sample.

Discussion

78. Dike structures were characterized in June 1978 by net-spinning hydropsychid caddisflies, tube-building chironomid larvae, and

clinging mayflies. The caddisfly Hydropsyche spp. was by far the dominant taxon collected, representing 86 percent of the total sample density. Although only the dike surface substrate was sampled during this effort, field observations indicated that highest macroinvertebrate densities (primarily tube-building chironomids and caddisflies) were associated with the surface substrate. Field observations also indicated that significant macroinvertebrate activity occurs much deeper within the dike structure; thus, the data obtained during this effort may not totally reflect actual assemblage composition and structure.

79. As evidenced by the high average benthic macroinvertebrate densities (536.4 organisms/rock sample) and diversity (7.3 taxa/rock sample) obtained from these samples, dike structures appear to provide a highly productive habitat for primarily lotic-adapted benthic macroinvertebrates. Based on data obtained from natural banks, the macroinvertebrate assemblage associated with these dike structures is similar to that associated with the solid, stable substrates provided by submerged trees, snags, and clumps of grass frequently found along the bank line of natural banks. However, the dike structure assemblage appears to be more diverse in composition, possibly due to the wide diversity of available microhabitats associated with the stone dike substrate.

Sampling considerations

80. As previously discussed, these data were obtained as part of a pilot investigation designed to develop quantitative sampling techniques for dike-associated benthic macroinvertebrate studies.* Two general conclusions concerning sampling considerations are summarized here.

81. First, most stream sampling techniques, such as sample collection and sampler deployment and retrieval by wading or with the aid of divers, are not appropriate for these dike structures due to the extreme turbulence, extreme water level fluctuations, and high current velocities typically associated with these structures. For example, great care would have to be taken when obtaining samples from these

* A report on this investigation is scheduled for publication in December 1981.

structures by hand or by wading, even for survey sampling purposes to avoid sampling substrate that has only recently been inundated and, thus, not yet fully colonized by macroinvertebrate organisms.

82. Second, the use of artificial substrate samplers, incorporating stone substrate of similar composition to that of the dike structure, is a viable sampling approach. However, remote deployment of these samplers (i.e., remote placement of the substrate samplers on top of the existing dike substrate) will not yield results that accurately reflect the structure and composition of the dike-associated assemblage. Colonization of samples in this manner is primarily by highly rheophilic taxa, such as the free-living leeches Hirudinea. This results in inaccurate sample estimates of both assemblage structure and composition; i.e., neither qualitative nor quantitative data are obtained in this manner.

83. A potential approach for obtaining quantitative data from these structures is the use of an inlaying technique for the substrate samplers. This inlaying technique basically consists of excavating substrate into a wire cage or basket and inlaying the rock-filled sampler into the excavated area so that the top of the sampler is flush with the surrounding substrate. Additional rock is then packed around the sampler to reestablish continuity of the rock substrate. Several researchers, including Mundie (1956), Radford and Hartland-Rowe (1971), Ulfstrand, Nilsson, and Anton (1974), and Hynes, Williams, and Williams (1976), have demonstrated the utility of this approach for sampling purposes. However, the main disadvantage of this approach for dike studies is that sampler deployment is limited to low flow conditions when the dike structures are completely emergent.

Revetted Banks

Results

84. Eighty-nine Shipek grab samples were obtained from the five revetted bank sites. From this effort, 126 organisms, representing 15 distinct taxa of benthic macroinvertebrates, were collected.

85. Sample densities averaged less than 1.0 organism/0.05 m² at

four of the five revetted banks. Current velocities were extreme and along most reaches of the revetted banks there was little or no sediment deposition. The low population of infaunal macroinvertebrates can be attributed in part to the lack of sediment. The upper half or more of the revetted bank is comprised of articulated concrete mattress (ACM) with no surficial sediment deposits. Also, sampling with benthic grabs proved to be an inefficient method of sampling this aquatic habitat. Grab samplers essentially scrape portions of the ACM and allow neither quantitative nor qualitative data. A few benthic macroinvertebrates were scraped from the ACM's sediment-free surface, primarily net-spinning hydropsychid caddisflies and free-living leeches.

86. Near the foot of the revetment and on the lower slopes of the bank, coarse sand and gravel sediments (primarily bed load) were frequently encountered. Samples from these stations contained very few benthic organisms.

87. Those species collected from revetted banks, exclusive of Walnut Point-Kentucky Bend Revetment, were Pseudochironomus richardsoni, Hydropsyche spp., Stenonema femoratum, Cyrnellus sp., Corbicula fluminea, and Chaoborus punctipennis. Most of these taxa were represented by single specimens (Table 7).

88. Macroinvertebrate density and diversity were higher at Walnut Point-Kentucky Bend Revetment than at the other revetted banks. Average total density for this revetted bank was 1.8 organisms/0.05 m². One station (station 1) was located in the lee of Walnut Point Dike Field (Figure 10), which caused a buildup of fine sand, silt-clay sediments over the revetted bank. In these fine sediments, an assemblage of benthic organisms composed of Chaoborus punctipennis, Limnodrilus spp., and other taxa presumably of drift origin were collected (Table 7). The average sample density at this station was 14.0 organisms/0.05 m².

Discussion

89. During sampling efforts, the conditions that existed at station 1 of Walnut Point-Kentucky Bend Revetment were atypical for revetted banks. Based on collections with the Shipek grab sampler, most revetted bank sampling stations were depauperate of aquatic macroinvertebrates.

However, a grab sampling technique was not adequate for sampling purposes within this aquatic habitat type during this sampling period.

90. Field observations indicate that this habitat appears to be a productive habitat for benthic macroinvertebrates. Remnants of pelycypod shells and hydropsychid caddisfly cases and larval chironomid tubes are numerous at low water. This observation was substantiated in part during this investigation by the occasional collection of hydropsychid caddisflies and leeches due to the scraping action of the Shipek grab sampler over the surface of the sediment-free revetment surface. Additionally, numerous mayfly burrows were observed at lower water where the revetment mattress had buckled over the underlying cohesive clay substrate. A potential value of this revetment mattress structure is the stabilization of the underlying cohesive clay substrate, which provides a unique habitat, primarily for the burrowing mayflies Tortopus incertus and Pentagenia vittigera (see paragraph 158). These unique taxa show a definite substrate preference for firm clay sediments and do not appear to be adaptive with regard to sediment type.

Sampling considerations

91. Field observations indicate that revetted banks are a potentially productive habitat for benthic macroinvertebrates. Evidence of benthic macroinvertebrate activity was observed on top of and in between the individual revetment mattress sections and within the underlying substrate. However, the grab sampling technique used during this effort was inappropriate for either qualitative or quantitative description of this habitat.

92. Because of the extreme turbulence, high current velocities, and the unique substrate associated with this habitat, new and innovative sampling techniques will have to be developed to adequately assess the relative aquatic habitat value for benthic macroinvertebrates within this habitat. An inlayed substrate sampling technique, similar to that recommended for dike structure studies, also appears to be the most practical approach to provide data for this habitat. Sampler design should not only incorporate the concrete mattress material, but also the underlying sediment, in order to provide data on the actual impact that

this revetment structure imposes on the natural bank habitat that it replaces.

Natural Banks

Results

93. From the five natural banks, 107 Shipek grab samples were collected. This comprised approximately 19 percent of the total samples taken during this sampling effort.

94. Overall, 1011 organisms, representing 26 distinct taxa, 7 orders, and 4 classes of benthic macroinvertebrates, were obtained. Class Insecta was by far the dominant group comprising 95.5 percent of the total sample. Immature insects collected included 6 genera of Ephemeroptera (mayflies), 4 genera of Trichoptera (caddisflies), and 9 genera of Diptera (midges). Two genera of Amphipoda were collected, as well as one genus of Pelecypoda and one genus of Oligochaeta.

95. Anconia Natural Bank. The natural bank at Anconia is approximately one mile long and lies in a straight reach of the river (Figure 11). The bank is undergoing moderate slumping, and numerous fallen trees are present. During sampling efforts bottom sediments varied from cohesive clays to coarse sand; at several stations, fine sand was predominant. Surface water temperature averaged 24.6°C; surface D.O. readings averaged 6.2 mg/l. Little horizontal variations in water quality parameters over the length of this site were found (Table 9).

96. Eighteen grab samples were obtained from this site with a Shipek grab sampler. Eighty-seven organisms, representing 11 distinct taxa, were collected with an average number of taxa of 1.5 taxa/0.05 m² and an average sample density of 4.8 organisms/0.05 m² (Table 8).

97. The burrowing mayfly Tortopus incertus was the most abundant taxon collected, comprising 64.4 percent of the total sample density (Table 8). Next in order of abundance (Table 8) were Pentagenia vittigera (8 percent), Hydropsyche spp. (6.9 percent), Limnodrilus spp. (6.9 percent), and Polypedilum sp. (5.7 percent).

98. Lakeport Natural Bank. Lakeport Natural Bank extends from a

straight reach of river adjacent to the main channel into American Cut-off (Figure 11). During sampling efforts, the average water surface temperature at this site was 26.3°C and ranged from 26.0 to 27.2°C. Surface D.O. readings were fairly constant, averaging 6.4 mg/l (Table 9).

99. This bank was not stable and was slumping rapidly prior to the June sampling period, except at the extreme upstream reach. Bottom sediments were predominantly coarse sand and gravel; cohesive clay sediments were encountered at a few stations. Fallen trees were numerous along the bank line.

100. Forty-two Shipek grab samples were obtained from this site (Figure 11). From this effort, 214 macroinvertebrate organisms were collected, representing 12 distinct taxa. The average sample density was 5.1 organisms/0.05 m²; the average number of taxa was 0.9 taxa/0.05 m² (Table 8). The net-spinning caddisflies Hydropsyche spp. were the most abundant taxon collected, representing 66.8 percent of the total sample density. The burrowing mayfly Tortopus incertus was the only additional taxon collected in abundance, representing 17.8 percent of the total sample density.

101. Island 88 Natural Bank. This bank is located at the downstream end of the temporary secondary channel (no flow at low water) behind Kentucky Bend Bar and is not directly associated with the main channel (Figure 8). During sampling efforts, the average water surface temperature at this site was 26.6°C and ranged from 26.1 to 27.0°C. Surface D.O. readings averaged 6.8 mg/l and ranged from 6.7 to 7.0 mg/l. Water quality data for this site are presented in Table 9.

102. This bank habitat was relatively stable prior to and during sampling efforts. Bottom sediments were predominantly cohesive clays, with coarse sand and mud/fine sands encountered at several sampling sites. Fallen trees and snags were present along the length of the bank line. Current velocities were moderate relative to main channel conditions.

103. Eighteen Shipek grab samples were obtained at this site. From this effort, 93 macroinvertebrate organisms were collected, representing 11 distinct taxa (Table 8). The average sample density was 5.2

organisms/0.05 m²; the average number of taxa collected was 1.7/0.05 m².

104. Two species of burrowing mayflies, Tortopus incertus and Pentagenia vittigera, were the most abundant taxa collected, representing 45.2 percent and 30.1 percent of the total sample density, respectively (Table 8). Next in the order of abundance were the amphipod Gammarus sp., the caddisflies Hydropsyche spp. and Potamyia flava, the burrowing mayfly Hexagenia limbata, and the oligochaete Limnodrilus udekemianus, representing 5.4, 5.4, 4.3, 3.2, and 2.1 percent of the total sample density, respectively.

105. Mayersville Natural Bank. The natural bank at Mayersville is located on the upstream approach into a bendway and on the concave bank (Figure 2). During sampling efforts, the average water surface temperature at this site was 27.7°C and ranged from 27.4 to 28.2°C. Surface D.O. readings averaged 6.7 mg/l and ranged from 6.3 to 7.7 mg/l. Additional water quality data for this site are given in Table 9.

106. This natural bank was relatively stable prior to sampling efforts and very few trees and snags were observed along the length of the bank line. Bottom sediments were typically cohesive clay. Current velocities were similar to main channel conditions and numerous eddies were observed.

107. Twenty-three Shipek grab samples were obtained at this site. From this effort, 616 aquatic macroinvertebrates were collected, representing 18 distinct taxa. The average sample density was 26.8 organisms/0.05 m²; the average number of taxa collected was 2.9/0.05 m².

108. The caddisflies Hydropsyche spp. and the burrowing mayfly Tortopus incertus were the most abundant taxa collected, representing 45.3 and 30.4 percent of the total sample density, respectively. The caddisfly Potamyia flava and the burrowing mayfly Pentagenia vittigera were the only additional taxa collected in significant numbers, representing 9.1 and 6.8 percent of the total sample density, respectively.

109. Seven Oaks Natural Bank. Seven Oaks is a short reach of natural bank located below Lakeport Revetment, just above Seven Oaks Dike Field (Figure 10). No water quality data were obtained at this site.

110. This bank was relatively stable prior to sampling efforts and very few trees and snags were observed along the length of the bank line. Bottom sediments were predominantly coarse sand. Current velocities were similar to those of the main channel.

111. Six Shipek grab samples were obtained from this site (Figure 10). From this effort, a single specimen of the oligochaete Limnodrilus udekemianus was collected.

Discussion

112. Natural banks of the Lower Mississippi River are characteristically dynamic. Field observations have shown that habitat type (with regard to substrate) may change within a 24-hour period because of constant slumping of the natural bank substrate. Currents vary from erosional (approaching adjacent main channel flow) along most reaches of natural bank to depositional in those areas where eddies are present. During study efforts bottom sediments varied within all of the natural banks sampled, ranging from coarse sand to cohesive clay to mud and fine sand. Fallen trees, snags, and submerged grasses were frequently encountered along the bank line within each site.

113. The natural bank macroinvertebrate assemblage was characterized in June 1978 by burrowing and clinging forms of insect larvae. Although both lotic and lentic forms were collected, lotic forms dominated in both total density collected and in total number of taxa. Lentic forms were restricted primarily to a few sampling stations within each site where eddy action was encountered, along with the deposition of finer grained sediments and presumably benthic drift.

114. The net-spinning caddisflies Hydropsyche spp. were numerically the most abundant taxon collected, representing 42.8 percent of the total natural bank sample density. It was the most abundant taxon collected at both the Lakeport and Mayersville sites (Table 8). However, this genus was only collected in 15.4 percent of the samples obtained from the five natural banks. Field observations during sampling efforts indicated that the majority of these organisms were collected from stations where clumps of grass and artifacts from tree limbs were collected along with the substrate samples. Apparently Hydropsyche spp., as well

as other clinging and sprawling macroinvertebrates collected from this habitat (which showed similar trends in occurrence in these natural bank samples), do not directly utilize the numerous burrow tubes created in the cohesive clay substrate by burrowing insect larvae as has been observed in other lotic systems with similar substrate conditions (i.e., soft chalk deposits). Field observations also indicated that these clinging and sprawling forms were associated primarily with submerged trees and clumps of grass encountered along the bank line of these sites.

115. The burrowing mayflies Tortopus incertus and Pentagenia vittigera were numerically the next most abundant taxa collected, representing 32.1 percent and 8.1 percent of the total natural bank sample density, respectively (Table 8).

116. Tortopus incertus was collected in 43.1 percent of the total natural bank samples. Pentagenia vittigera was collected in 22.3 percent of the total samples. These taxa were the numerically codominant infaunal organisms found in the various natural bank bottom sediments and reached their highest densities within the cohesive clay sediments.

117. Other genera that were occasionally collected at most natural bank sites (Table 8) included the net-spinning caddisfly Potamyia flava (6.2 percent of total sample density), the amphipod Gammarus sp. (1.1 percent), the pelecypod Corbicula fluminea (1.2 percent), the oligochaete Limnodrilus spp. (1.1 percent), and the chironomid Polypedilum sp. (1 percent).

118. The overall average sample density of benthic macroinvertebrates collected from the five natural bank sites was 9.4 organisms/ 0.05 m^2 and ranged from a minimum of 0.17 organisms/ 0.05 m^2 within Seven Oaks Natural Bank to a maximum of 26.8 organisms/ 0.05 m^2 within the Mayersville Natural Bank. Distinct taxa collected from each site ranged from a minimum of 1 taxon from Seven Oaks Natural Bank to a maximum of 18 distinct taxa from the Mayersville Natural Bank. The average overall number of taxa per sample was 1.4 taxa/ 0.05 m^2 and ranged from a minimum of 0.17/ 0.05 m^2 within Seven Oaks Natural Bank to a maximum of 2.91/ 0.05 m^2 within the Mayersville Natural Bank. The highest average

macroinvertebrate sample density, total number of distinct taxa collected, and average number of taxa collected per sample within the Mayersville Natural Bank habitat can be attributed in part to the greater relative stability (based on field observations) of this natural bank due to a predominance of cohesive clay substrate and to numerous eddies along the bank line at this site which allowed for the deposition of fine-grained sediments along with drifting macroinvertebrate organisms.

Sampling considerations

119. Variance component analysis for total density and number of taxa indicates that for the five natural bank sites, the total density variance among sites component explained only 0.11 percent of the total variance. The remaining 99.89 percent of the total variance was explained by the variance among stations within sites (10.93 percent) and the variance among replicates within stations and sites (88.96 percent) (Table 10). This same trend is evident with respect to the number of taxa. This suggests that replicated subsampling is appropriate, particularly if an analysis of variance approach is incorporated into the experimental field sampling design.

Abandoned Channels

Results

120. The five abandoned channel sites were all characterized by slack-water (lentic) conditions and unconsolidated silt-clay (mud) substrates during this sampling period. Water quality data for each site are presented in Table 11.

121. Overall, 7004 organisms, representing 39 distinct taxa, 11 orders, and 5 classes of benthic macroinvertebrates, were collected. Insecta collected included 14 genera of Diptera, 3 genera of Ephemeroptera, 2 genera of Lepidoptera, and 1 genus each of Trichoptera and Hemiptera. Mollusca collected included 3 genera of Gastropoda and 1 genus of Pelecypoda. Also collected were 4 genera of Oligochaeta, 2 genera of Isopoda, and 1 genus each of Decopoda and the leeches Hirudinea.

122. Average macroinvertebrate sample density for the five abandoned channels was 70.04 organisms/0.05 m². The average number of taxa collected was 5.2/0.05 m².

123. Matthews Bend. The average water surface temperature at this site was 28.5°C and ranged from 25.8 to 30.5°C. Surface D.O. readings averaged 8.3 mg/l and ranged from 4.7 to 11.2 mg/l. Pronounced D.O. depletion and thermal stratification were evident at the midchannel stations within this site with near-bottom readings for D.O. and temperature averaging 1.1 mg/l and 25.9°C. Additional water quality data for this site are presented in Table 11.

124. Eighteen macroinvertebrate samples were obtained from this site with a Ponar grab sampler (0.05 m²) (Figure 6). Overall, 1709 macroinvertebrate organisms representing 17 distinct taxa were collected. The average sample density was 94.9 organisms/0.05 m²; the average number of taxa was 4.4 taxa/0.05 m². Chaoborus punctipennis was the most abundant taxon collected, representing 68 percent of the total sample density. Several species of the oligochaete Limnodrilus spp., including L. hoffmeisteri, L. cervix, and L. claparedianus, accounted for 19 percent of the total sample density. The pelycypod Sphaerium transversum comprised 11 percent of the total sample density. The chironomids Procladius subletti and Coelotanypus scapularis were also frequently collected but in small numbers (Table 12). No macroinvertebrate taxa collected were solely unique to this abandoned channel site.

125. Carolina Chute. The average water surface temperature for this site was 32.8°C and ranged from 31.5 to 34°C. The average surface D.O. reading was 9.8 mg/l and ranged from 8.3 to 11.0 mg/l. Water depths within this site were relatively shallow (1 to 1.5 m) and pronounced D.O. depletion and thermal stratification were not readily apparent. Water quality data for this site are presented in Table 11.

126. Eighteen macroinvertebrate grab samples were obtained from this site with a Ponar grab sampler (Figure 3). Overall, 857 macroinvertebrate organisms were collected, representing 14 distinct taxa (Table 12). The average sample density was 47.6 organisms/0.05 m²; average number of taxa collected was 2.9/0.05 m². Chaoborus punctipennis

was by far the most abundant taxon collected, representing 86 percent of the total sample density. The oligochaete Limnodrilus spp. accounted for 12 percent of the total sample density and was represented by the species L. cervix and L. hoffmeisteri.

127. Seven macroinvertebrate taxa were collected in Carolina Chute that were not collected from the other abandoned channels. These included the dipteran larvae Parachironomus sp., Stratiomysis sp., Lauterborniella sp., and Kieffurulus sp., the lepidopteran Arzama sp., and the hemipteran Graptocorixa sp.

128. Lakeport Chute. The average water surface temperature for this site was 31.5°C and ranged from 30 to 32.5°C. Surface D.O. readings averaged 8.4 mg/l and ranged from 7.5 to 9.5 mg/l. Water depths within this site were relatively shallow (1 to 1.5 m) and pronounced D.O. depletion and thermal stratification were not readily apparent. Water quality data for this site are presented in Table 11.

129. Sixteen macroinvertebrate samples were obtained from this site with a Ponar grab sampler (Figure 11). Overall, a total of 1319 macroinvertebrate organisms, representing 13 distinct taxa, were collected (Table 12). The average sample density was 82.8 organisms/ 0.05 m^2 ; the average number of taxa was $5.6/0.05\text{ m}^2$. The predaceous midge Tanypus stellatus was the most abundant taxon collected, representing 64 percent of the total sample density. Next in order of total abundance were Chaoborus punctipennis (17.7 percent), the oligochaete Limnodrilus spp. (6 percent), the pelecypod Sphaerium transversum (5 percent), and the chironomids Coelotanypus scapularis (4 percent) and Chironomus spp. (2 percent). No macroinvertebrate taxa collected were solely unique to this abandoned channel.

130. Moon Chute. The average water surface temperature for this site was 28.8°C and ranged from 26.5 to 30°C. Surface D.O. readings averaged 6.1 mg/l and ranged from 4.7 to 7.5 mg/l. Because of the shallow water depths within this site (1 to 1.5 m), thermal stratification and pronounced D.O. depletion were not readily evident. Water quality data for this site are presented in Table 11.

131. Eighteen macroinvertebrate grab samples were obtained from

this site with a Ponar grab sampler (Figure 7). Overall, 1015 macro-invertebrate organisms, representing 16 distinct taxa, were collected (Table 12). The average sample density was 56.4 organisms/0.05 m²; average number of taxa was 6.1/0.05 m². The oligochaete Limnodrilus spp. was the most abundant taxon collected, representing 50.04 percent of the total sample density. Next in order of total abundance were the dipteran larvae Chaoborus punctipennis (34.08 percent), Tanypus stellatus (8.1 percent), and Coelotanypus scapularis (4.2 percent), and the pelecypod Sphaerium transversum (1.5 percent).

132. Three macroinvertebrate taxa were collected in Moon Chute that were not collected within the other abandoned channel sites. These were the midges Einfeldia natchitochae and Cryptochironomus sp., and the mayfly Caenis sp.

133. Lake Lee. This is the only one of the five abandoned channels sampled classified as an oxbow lake. Average water surface temperature for this site was 27.6°C and ranged from 25.3 to 29.5°C. Surface D.O. readings averaged 11.6 mg/l and ranged from 9.6 to 14.0 mg/l. Thermal stratification and near-bottom D.O. depletion were strongly evident within this site. The average near-bottom D.O. reading was 1.8 mg/l, and the average near-bottom water temperature was 20.7°C with the minimum near-bottom recorded temperature of 16.0°C. Additional water quality data for this site are presented in Table 11.

134. Thirty macroinvertebrate samples were obtained from this site with a Ponar grab sampler (Figure 11). Overall, 2104 macroinvertebrate organisms, representing 23 distinct taxa, were collected (Table 12). The average sample density was 70.1 organisms/0.05 m²; the average number of taxa collected was 6.9/0.05 m². The oligochaete Limnodrilus spp. and the pelecypod Sphaerium transversum were the two most abundant taxa collected, representing 36.3 percent and 25.6 percent of the total sample density, respectively. Next in order of total abundance were the taxa Coelotanypus scapularis (14.8 percent), Chaoborus punctipennis (11.5 percent), Chironomus sp. (5 percent), Campeloma sp. (1.8 percent), and Chironomus plumosus (1.5 percent).

135. The snails Viviparus sp. and Campeloma sp. and the

hydropsychid caddisfly Potamyia flava were collected in Lake Lee and in no other abandoned channel site. P. flava is typically associated with flowing waters and may have been introduced to the lake during periods of confluence with the river. Two species of Chironomus, C. plumosus and C. sp., were commonly collected in Lake Lee samples. C. plumosus was rare or absent in the other abandoned channel sites. C. sp., a very large (up to 4 cm total length) orange species, was only abundant in Lake Lee and Lake Port.

Discussion

136. The abandoned channel benthic macroinvertebrate assemblage was characterized in June 1978 by various dipteran larvae, fingernail clams, and oligochaetes (Table 12). Although dominant taxa and assemblage structure differed among the five abandoned channel sites, assemblage composition was, for the most part, similar at each site.

137. Chaoborus punctipennis was the most abundant taxon collected, representing 34 percent of the total abandoned channel sample density; it was abundant in all five of the aquatic sites sampled ranging from a minimum of 11.6 percent of total sample density within Lake Lee to a maximum of 86 percent of total sample density within Carolina Chute. It was the most abundant taxon collected in Matthews Bend and Carolina Chute and the second most abundant taxon collected within Lake Port and Moon Chute. It was collected in 93 of the 100 total grab samples obtained from the five abandoned channels (Table 12).

138. The oligochaete Limnodrilus spp. was the second most abundant taxon collected overall and accounted for 25 percent of the total abandoned channel sample density. This genus was represented by the species L. hoffmeisteri, L. cervix, L. claparedianus, L. claparedianus/cervix, and numerous L. immatures. Limnodrilus spp. was fairly abundant in all five of the sites sampled and ranged from a minimum of 6 percent of total sample density within Lake Port to a maximum of 49 percent of total sample density within Moon Chute. It was the most abundant taxon collected in Lake Lee and Moon Chute and the second most abundant taxon collected within Matthews Bend and Carolina Chute. This genus was

collected in 79 percent of the 100 total grab samples obtained from the five abandoned channel sites (Table 12).

139. The predaceous midge Tanypus stellatus was the third most abundant taxon collected, representing 13.3 percent of the total abandoned channel sample density. Although T. stellatus was the most abundant taxon collected in Lake Port (64.5 percent), it was either totally absent in sample collections from the other sites or present only in very small numbers. This genus was collected in 29 of the 100 total grab samples obtained from the abandoned channel sites (Table 12).

140. The fingernail clam Sphaerium transversum and the dipteran larvae Coelotanypus scapularis were the only remaining taxa present in significant numbers, representing 11.6 percent and 10.7 percent of the overall total sample density, respectively. These taxa were commonly collected in samples from all but Carolina Chute. Sphaerium transversum was collected in 53 percent of the 100 total samples obtained; Coelotanypus scapularis was collected in 58 percent of the 100 total samples obtained. Each species was characteristically present at relatively low levels of abundance. Additional macroinvertebrate taxa collected in three or more of these sites which may be considered as characteristic of the abandoned channels included the midges Chironomus spp. and Procladius subletti, Hirudinea, the oligochaete Ilyodrilus sp., and the gastropod Physa hawnii.

141. The overall average macroinvertebrate sample density from the five abandoned channels was 70.04 organisms/0.05 m² and ranged from a minimum of 47.6 organisms/0.05 m² in Carolina Chute to a maximum of 94.9 organisms/0.05 m² within Matthews Bend (Table 12). The total number of distinct taxa collected at each site ranged from a minimum of 14 in Lake Port to a maximum of 23 taxa collected within Lake Lee. Average overall number of taxa per sample was 5.2 taxa/0.05 m² and ranged from a minimum of 2.9 taxa/0.05 m² in Carolina Chute to a maximum of 6.9 taxa/0.05 m² within Lake Lee.

Sampling considerations

142. Variance components analysis for the total density and number of taxa was conducted to provide information on the appropriateness

of the sampling scheme employed and for future experimental design considerations (Table 13).

143. The results indicate that for the five abandoned channel sites sampled, the component of total density variance attributable to variance among the sites sampled was only six percent of the total variance. The remaining 94 percent of the total variance was about equally divided between the variance among stations within sites and the variance among replicates within stations and sites. Spatial variation in total density is evidently as great on a small scale, i.e., among replicates within stations and sites, as it is among stations within each abandoned channel sampled (bank line stations and midchannel stations). Variance component analysis for the number of taxa showed a somewhat different trend. This analysis indicated that greater variation in number of taxa occurred between the five sites and between replicated subsamples than between stations (midchannel and shoreline) within each site. Both the total density and the number of taxa variance component analyses indicated that if an ANOV approach is used for future macroinvertebrate comparisons between sites classified as abandoned channels, a replicated subsampling approach at each station is a desirable sampling design consideration.

Other Aquatic Habitats

Results

144. Permanent secondary channels. American Cutoff is the only permanent secondary channel within the study area. During sampling efforts, this habitat was essentially riverine in nature with high current velocities and shifting coarse sand and gravel sediments encountered at all sampling stations. Water quality variables were fairly constant over the length of the habitat and were similar to those of the main channel (Table 14).

145. Twelve macroinvertebrate grab samples were obtained from this habitat with a Shipek grab sampler (Figure 11). Three organisms were collected from the 12 grab samples. These included one specimen

each of Tortopus incertus, Corbicula fluminea, and Hydropsyche spp.

146. Temporary secondary channels. Kentucky Bend Chute is the only temporary secondary channel within the study area (Figure 8). During sampling efforts, current velocities ranged from moderate (relative to main channel conditions) at midchannel stations to slack at the near shore stations. Sediments ranged from coarse sand at the midchannel stations to predominantly fine sands at the near shore stations. At several near shore stations with slack-water conditions, a thin layer of silt-clay (mud) sediment had been deposited over the underlying coarse sand substrate. Shallow water depths (1 to 1.5 m) were recorded at all sampling stations. Water quality data for this site are presented in Table 14.

147. Twenty-four macroinvertebrate grab samples were obtained from this site with a Shipek grab sampler (Figure 8). From this effort, 51 organisms, representing 14 distinct taxa, were collected. The average sample density was 2.1 organisms/0.05 m²; average number of taxa was 1.0/0.05 m². The most abundant taxa collected included the burrowing mayflies Tortopus incertus, Pentagenia vittigera, and Hexagenia limbata, and the pelecypods Sphaerium transversum and Corbicula fluminea. Oligochaetes and dipteran larvae were also present (Table 15).

148. Main channel. The main channel represents a large percentage of the total available or potential habitat for benthic macroinvertebrates within the study reach. Because of high current velocities and extreme turbulence, the water column within this habitat was essentially homogeneous during sampling efforts with little vertical or spatial variation observed in water quality variables measured (Table 14). Coarse sand and gravel sediments were obtained at all established sampling stations.

149. Eighteen samples were obtained from the main channel during sampling efforts with a Shipek grab sampler. Nine organisms, representing 6 distinct taxa, were collected (Table 15). Taxa collected were a mixture of both lotic- and lentic-adapted organisms, including Limnodrilus spp., Tortopus incertus, Hexagenia limbata, Corbicula fluminea, Baetis sp., and Chernovskia orbicus.

150. Sandbars. The sandbar at Kentucky Bend Bar was the only sandbar sampled (Figure 8). The habitat was generally characterized by coarse sand sediments and, at several sites with eddy or backflow conditions, by fine to medium sand or a thin layer of silt-clay material overlying coarse sand. Water quality characteristics were similar to those of the main channel (Table 14).

151. Eight grab samples were obtained from this habitat with a Shipek grab sampler. From this effort, 12 organisms, representing 7 distinct taxa, were collected (Table 15). Taxa collected included Chaoborus punctipennis, the pelecypods Corbicula fluminea and Sphaerium transversum, the burrowing mayflies Pentagenia vittigera, Tortopus incertus, and Hexagenia limbata, and the oligochaete Limnodrilus spp.

Discussion

152. The main channel, secondary channel (permanent and temporary), and sandbar habitats were characterized by a diverse variety of both lotic- and lentic-adapted macroinvertebrate taxa in very low numbers. From the 62 Shipek grab samples obtained from these sites, 75 organisms, representing 16 distinct taxa were collected (Table 15).

153. The shifting unstable coarse sand and gravel substrates that predominate within these high energy aquatic habitat types are probably unsuitable for the establishment of a distinct and productive benthic macroinvertebrate community. In general, the majority of organisms and taxa collected from each area were found in small transient microdepositional areas created by backflows or eddies. Substrates within these microdepositional areas were predominantly fine sand and silt/clay deposits overlying coarse sand and gravel. The location and areal extent of these habitats varies significantly with changes in river stage.

154. Because of the mixed and highly diverse lotic and lentic composition of these macroinvertebrate assemblages and their predominance within depositional sites, their origin is most likely from main channel macroinvertebrate drift. This is substantiated by diel drift studies conducted during this general time period (Report 4 of this series). This drift appears to originate in large part from the abandoned channel and natural banks and from the stable substrates created

by the construction of dike (and possibly revetment) structures.

Summary Discussion

155. From the nine aquatic habitats, a total of 20,565 organisms, representing 72 distinct taxa, 17 orders, and 5 classes of benthic macroinvertebrates were collected. From the 578 Ponar and Shipek grab samples, 9,839 organisms, representing 69 distinct taxa, 15 orders, and 5 classes of benthic macroinvertebrates, were collected. From rock dike structures, 10,726 organisms, representing 28 distinct taxa, 13 orders, and 4 classes of benthic macroinvertebrates, were collected during this sampling effort. Table 16 provides a summary of data obtained from each of the nine aquatic habitat types.

156. The dike structures were the most productive benthic macroinvertebrate habitat sampled during this effort. Although the data obtained from these structures are not directly comparable to grab sample data, the high average densities (536.4 organisms/rock sample) and the number of taxa (7.3 taxa/rock sample) collected from these samples are indicative of the habitat associated with these structures during this sampling period. Twenty-eight distinct taxa were collected from the dike structures. The assemblage was predominantly lotic in nature and was distinctly characterized by net-spinning hydropsychid caddisflies, tube-building chironomid larvae, and clinging mayflies. The caddisflies Hydropsyche spp. were by far the most abundant taxon collected, representing 86 percent of the total dike structure sample density. During sampling efforts, current velocities around each dike sampled approached those of the main channel, and water turbulence was extremely high.

157. Abandoned channels were the second most productive habitat sampled. The average total sample density obtained from this habitat type was 70.04 organisms/0.05 m²; the average number of taxa collected was 5.2/0.05 m². This habitat was characterized by lakelike conditions and unconsolidated silt-clay bottom sediments. Thirty-nine distinct benthic macroinvertebrate taxa were collected from this habitat. The

macroinvertebrate assemblage was distinctly lentic in nature and was characterized by various dipteran larvae, fingernail clams, and oligochaetes. Matthews Bend, the only abandoned channel that was confluent with the main channel during sampling efforts, had the highest average density per sample (94.9 organism/0.05 m²) of the five sites sampled. Lake Lee, the only abandoned channel sampled that is classified as a true oxbow lake, contained the most diverse benthic macroinvertebrate assemblage (23 distinct taxa, 6.9 taxa/0.05 m²) of the five abandoned channels.

158. Natural banks were the next most productive habitat. The average sample density for this habitat was 9.4 organisms/0.05 m²; the average number of taxa was 1.4/0.05 m². During sampling efforts, this habitat type was highly dynamic in nature due to constant caving of the natural bank substrate. Currents varied from highly erosional along most reaches to depositional in those areas where eddies were present. Bottom sediments were predominantly highly cohesive clays, but ranged from coarse sand to mud and fine sand. Fallen trees, snags, and submerged grasses were frequently encountered. The associated benthic macroinvertebrate assemblage was predominantly lotic in nature and was characterized by burrowing and clinging forms of insect larvae. Lentic forms, such as oligochaetes and certain dipteran larvae, were restricted primarily to the few sampling stations within each site sampled where eddy action was encountered, along with the deposition of fine-grained sediments and presumably benthic drift. The predominant infaunal forms within this habitat were two species of burrowing mayflies, Tortopus incertus and Pentagenia vittigera. These taxa were most abundant within highly cohesive clay substrates. Although clinging forms of insect larvae (primarily caddisflies and sprawling mayflies) were collected in fairly high numbers from this habitat, the majority of these taxa were obtained from sampling stations where clumps of grass and artifacts from tree limbs were collected along with the sediment samples. Based on this sampling effort, the Mayersville Natural Bank was the most productive of the five natural banks sampled in terms of both average total density and the number of taxa collected. This productivity was

attributed in part to the greater relative stability (based on field observations) of this site due to a predominance of highly cohesive clay substrates and in part to numerous eddies along the bank line, which allowed for the deposition of fine-grained sediment along with drifting macroinvertebrate organisms.

159. Dike fields were characterized during this sampling effort by a highly diverse variety of both lotic- and lentic-adapted benthic macroinvertebrate taxa at fairly low levels of abundance. The average total density per sample for this habitat type was 7.4 organisms/0.05 m²; the average number of taxa per sample was 0.9/0.05 m². Thirty-two distinct taxa were collected from this habitat type, which was second only to the abandoned channels (39 distinct taxa). The four dike fields sampled varied noticeably with respect to benthic macroinvertebrate composition and structure. This variance is attributed in large part to differences in the diversity and type of bottom sediments found within each site. The majority of organisms collected from each site were obtained either from small reaches of clay bank substrates or from micro-depositional sites. The mixed lotic and lentic composition of the taxa collected indicate that, for this sampling period, a characteristically distinct benthic macroinvertebrate assemblage did not occur within this habitat type. The highest sample densities, average number of taxa, and total number of distinct taxa were collected from the Lower Cracraft Dike Field. Based on the high abundance of lentic-adapted taxa collected from this habitat, it is hypothesized that certain of these dike fields may serve as secondary sites for the origin of drifting invertebrate organisms (principally lentic) during periods of lower river stage when pool formation occurs within these dike fields. In this sense, the dike fields may serve as an extension of abandoned channels under low flow conditions when the majority of abandoned channels are totally isolated from the main channel aquatic ecosystem.

160. Based on samples obtained with a Shipek grab sampler, revetted banks were relatively depauperate of benthic macroinvertebrate organisms during this sampling period. However, a grab sampling technique was totally inadequate for either qualitative or quantitative

sampling purposes in this habitat. Field observations during and after this sampling effort indicate that this habitat is fairly productive with regard to benthic macroinvertebrates. Evidence of macroinvertebrate activity was observed on top of and in between the individual revetment mattress sections and within the underlying substrate. A potential value of this ACM structure is the stabilization of the natural bank clay substrate which provides a unique habitat primarily for the burrowing mayflies Tortopus incertus and Pentagenia vittigera. These unique taxa show a definite substrate preference for firm clay sediments and do not appear to be adaptive with regard to substrate type.

161. The main channel, secondary channel, and sandbar sampled during this effort were all characterized by a diverse variety of both lotic- and lentic-adapted benthic macroinvertebrate taxa at low levels of abundance. The unstable coarse sand and gravel sediments that were predominant in each of these high energy habitats are probably unsuitable for the establishment of a distinct and productive benthic macroinvertebrate assemblage. In general, the majority of organisms and taxa collected from these habitats were found in transient microdepositional areas within each site created by eddy action. Because of the mixed lotic-lentic composition of the taxa collected and their predominance within deposited zones, the origin of these taxa is in all probability from main channel macroinvertebrate drift.

PART V: CONCLUSIONS

162. Based on this sampling effort, three aquatic habitats within the study area were characterized by distinct benthic macroinvertebrate assemblages. These included abandoned channels, characterized by a lentic assemblage composed primarily of oligochaetes, dipteran larvae, and fingernail clams; natural banks, characterized by a lotic assemblage composed primarily of unique burrowing mayflies and clinging macroinvertebrates (principally caddisflies); and dike (and possibly ACM revetment) structures, characterized by a lotic assemblage composed primarily of net-spinning caddisflies, tube-building chironomid larvae, and clinging mayflies. The key to the habitat value of these three habitats for benthic macroinvertebrates appears to be habitat (substrate) stability. The remainder of the habitats sampled (dike fields, main channel, sandbars, permanent and temporary secondary channels, and revetted banks) were primarily characterized by shifting, unstable coarse sand and gravel sediments. The mixed and highly diverse lotic and lentic composition of these assemblages and the predominance of these assemblages within microdepositional zones within each habitat indicate that their origin is primarily from macroinvertebrate drift.

163. Variance component analysis was used to assess the adequacy of the infaunal field sampling design used during this sampling efforts and for input into future experimental sampling design considerations. These variance components are additive and included variance among replicates within stations and sites, variance among stations within sites, and variance among aquatic sites components. According to these analyses, variation in the number of taxa collected and generally in the sample densities was on a small scale (i.e., between replicate samples within a sampling station) as great as or greater than on a large scale (i.e., among stations within each aquatic habitat sampled). Thus, replicated subsampling appears to be a desirable field sampling design consideration, particularly if an ANOV approach is to be used for hypothesis testing. The only significant deviation to this was within the dike fields. Variance component analysis for this habitat indicated

that most of the variance (particularly for total density) was among stations within sites. This was attributed to the extremely patchy sediment distribution and indicates that a stratified random field sampling design based on sediment type is most appropriate for this habitat type. In order to develop an effective stratified design, a field reconnaissance of sediment types should be undertaken prior to each sampling period in order to account for changes in sediment distribution as a function of major changes in river stage.

164. The dike and revetment structures appear to provide viable habitats for benthic macroinvertebrate organisms. However, because of the materials comprising these structures, innovative sampling techniques are required to assess their relative habitat value. For dike structures, most conventional stream sampling techniques (such as sampling by wading or with the aid of divers) are not practical due to the extreme velocities, turbulence, and river stage fluctuations encountered within the study area. Substrate samplers, using substrates similar in size to that comprising the dike structures, appear to be suitable for sampling purposes. However, preliminary data indicate that those samplers will have to be inlaid into the dike structure to provide representative estimates of assemblage composition, density, and structure. Because of the diversity of benthic macroinvertebrate substrates (micro-habitats) associated with the revetted banks, inlaid substrate samplers are also required to obtain satisfactory assemblage composition data from these sites.

PART VI: RECOMMENDATIONS

165. As discussed in Part I, a habitat concept should be applied within the study area to define the ecological value of dike and revetment structures (and associated aquatic habitats) to the riverine ecosystem, relative to other distinct aquatic habitat types. Concurrent studies of a variety of habitats associated with study area dike and revetment structures should also be conducted. Maximum ecological value, biological productivity, etc. associated with the habitats should be assessed, related to, and defined in terms of closely associated physical and water quality factors. The factors, in turn, can be used to develop ecologically compatible dike and revetment design alternatives.

166. Data obtained during this study period indicated that natural banks, dike fields, abandoned channels, revetted banks, and dike structures were the primary sources of benthic macroinvertebrate production. While neither quantitative nor qualitative data were obtained from revetted banks, field observations showed these areas to have high production potential. These habitats comprised an estimated 54 percent (Table 1) of total aquatic habitat within the study area. These habitats should receive intensive long-term study to define the overall contribution of each to the river ecosystem and in particular to the river fishery.

Natural Banks

167. Detailed benthic community and population ecology studies should be undertaken within the natural bank habitats. These natural banks provide a valuable habitat for several substrate-specific species of burrowing mayflies for which very little population ecology data are presently available. These data are essential in assessing the ecological value of this habitat type in order that predictions may be made as to the effect of bank stabilization efforts which have direct impact on these areas.

Dike Fields

168. Study results indicated that several of the dike fields sampled are effective collectors of main channel benthic drift during moderate river stages. These data also suggest that dike pool formation during low-flow conditions may also be of significant ecological importance to the river ecosystem.

169. Intensive long-term comparative studies should be conducted within selected study area dike field pools. Pool selection should include as wide a variety of physical (pool width, depth, substrate type, flow, etc.) and water quality characteristics as possible in order to define habitat conditions most appropriate to meet environmental quality objectives.

Abandoned Channels

170. Concurrent sampling should be undertaken within this habitat type. These data should provide valuable input into defining optimum physical and water quality characteristics required to meet environmental quality objectives associated with dike fields.

Revetted Banks

171. Field observations during sampling efforts indicated that bank revetment may be of ecological value in stabilizing the natural bank macroinvertebrate habitat as well as in providing additional substrate diversity for aquatic macroinvertebrates.

172. The recommended inlaid sampling technique (to include revetment substrate as well as underlying substrate) for this habitat should also be fully field-tested and refined prior to intensive study within this habitat type.

Dike Structures

173. Initial data indicate that this was the most productive habitat type sampled during the pilot study. The macroinvertebrate assemblage associated with these structures is similar to that associated with solid substrates provided by submerged trees, snags, and clumps of grass frequently found along the bank line of the natural banks.

174. An inlaying sampling technique that basically consists of excavating substrate into a wire cage or basket and inlaying the rock-filled sampler into the excavated area so that the top of the sampler is flush with the surrounding substrate appears to be a productive approach for obtaining quantitative data. This sampling technique, however, should be fully field-verified prior to intensive sampling efforts within this habitat type.

175. Various physical variables such as stone size, elevation of dike structures, and current velocity may affect densities as well as diversity of aquatic macroinvertebrates within this habitat type. Sampling schemes designed for this particular habitat should include a variety of these variables in order that possible correlations may be made with regard to the benthic communities and physical variation among the dike structures being studied. This information could in turn be implemented into design criteria for dike structures to enhance the environmental quality of this habitat type.

Other Habitats

176. Study results indicate that during this study period, main channel, sandbar, and secondary channel habitats did not contain distinctive macroinvertebrate assemblages. Benthic organisms obtained from these habitats were a diverse collection of both lotic and lentic taxa, found primarily within depositional sites, presumably originating from main channel benthic drift.

177. These habitats or depositional zones within each habitat are undoubtedly of importance to the river fishery, particularly for

feeding purposes. The selection of appropriate habitats and sites should be based in large part on fishery data obtained from this study (see Report 5 of this series) but should also include intensive sampling efforts within selected depositional zones. Data selection should include benthic sampling, benthic drift dynamics and ecology, and detailed fish food habitat studies.

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Table 1
 Aquatic Habitat Descriptions, Characterization, and Relative Surface Area
 Within the Study Area, June 1978

Habitat Type	Aquatic Habitat Definition*	Habitat Description	Percent of Total Aquatic Habitat by River Stage
Dike Fields	The portion of the river encompassing a series of transverse or vane dikes and the associated pools and sandbars.	Current varies from main channel flows at high water to reduced to slack at low water. Turbidity decreases at low water stages. Substrate types vary from mud to coarse sand and gravel. Deep plunge pools often exist below the dikes. Silt deposition occurs within the dike pools during falling river stages.	29
Dike Structures	Structures constructed of relatively impermeable stone riprap. Generally dikes are of the transverse type which extend from the bank perpendicular into the river channel past the point of highest current velocities; an extension or L-head may be placed at the channel end of a dike, parallel to the main axis of the current, to retard scouring and turbulence.	Water velocity is typically high and in the vicinity of the dike may be extremely turbulent. Stones making up the structure vary in weight from 5000 lb to 1 lb. Some deposition occurs on the dike structures during falling river stages. Most dikes within study area are totally emergent at +12-ft river stage (Vicksburg gauge).	Not calculated
Revetted Banks	The portion of the river having a revetment structure and extending from the bank line to the toe of the revetment structure.	Currents, turbulence, and turbidity approximate main channel conditions. Substrate consists generally of revetting material, but isolated areas of sand and sand-silt are present. Willow trees protruding through the upper bank paving are common.	5

(Continued)

* Water depth contours are based on an established low water reference plan (IWRP) for this waterway.

Table 1 (Continued)

Habitat Type	Aquatic Habitat Definition	Habitat Description	Percent of Total Aquatic Habitat by River Stage
Natural Banks	Natural banks extend from the edge of the water to the floor of the channel, typically the -30-ft contour.	Turbulence and turbidity similar to main channel conditions. Current velocity reduced compared to main channel flow except during high water stages. Sediment types range from mud, fine sand, coarse sand, to consolidated clays. Fallen trees protrude from the bank as a result of bank slumping.	1
Abandoned Channels	That portion of the river system consisting of old, abandoned river channels measured from their confluence with the main river channel to their head, occurring between the 0-ft contour on either bank, and having slack water, except at flood stages. Also floodplain water bodies or lakes not confluent with the main river channel, except at high-flow river stages.	Slack-water habitats except during high flow. Sediment type typically mud. Average depth = 4 m.	19
Permanent Secondary Channels	That portion of the river flowing through a channel that carries less than 40 percent of the discharge and maintains flow throughout the year. The channel is between the -1-ft contour on each bank.	Shallow at the upstream end (-10-ft LWRP) and deepens to -40-ft LWRP near the steep bank, and shallows to -20-ft LWRP at the downstream end. Current varies from moderate to approaching main channel velocities. Substrate primarily sand.	2
Temporary Secondary Channels	The portion of river flowing through a channel that carries less than 40 percent of the discharge, exists only during high flows, may consist of only slack-water pools during low flows, and is at an elevation greater than the 0-ft contour.	Current velocities slightly slower than main channel flows during high water. Sediment type is typically sand. Bottom contours are irregular and areas of standing water are present at low flows.	3

(Continued)

(Sheet 2 of 3)

Table 1 (Concluded)

Habitat Type	Aquatic Habitat Definition	Habitat Description	Percent of Total Aquatic Habitat by River Stage
Main Channel	Lies between the -10-ft contour on either bank, or in the case of bendways, between the -10-ft contour on the convex bank and the toe of the steep natural bank or revetment on the concave bank as defined by the 40-ft contour.	Maximum recorded current velocity - 15 ft/sec x current velocity - 3-6 ft/sec High turbulence Bottom sediments unstable (typically coarse sand and gravel) Average bed load transport (Vicksburg) - 1 million yd ³ /day High turbidity	29
Sandbars	The portion of river adjacent to a sandbar and extending out to the main channel (-10-ft contour).	Shallow with reduced current. Substrate is primarily sand and gravel with patches of silt, fine and coarse sand. Size of sandbars varies considerably with river stage due to the gradual slope between the +10 ft and -10-ft LWRP.	8

Table 2
Dike Field Habitat--Macroinvertebrate Data Summary
for June 1978 Sampling Effort

Taxon	Lower Cracraft	Island 86	Seven Oaks	Leota	Total Abundance Density	Percent of Total Abundance	Frequency of Occurrence (Percent of Total Habitat Sample)
Annelida							
Oligochaeta							
<i>Branchiura sowerbyi</i>	3		2	1	6	0.37	2.3
<i>Dero</i> sp.	1				1	0.06	0.5
<i>Limnodrilus cervix</i>	184	5	6	2	197	12.14	11.3
<i>Limnodrilus hoffmeisteri</i>	17	1	5		23	1.42	5.4
<i>Limnodrilus profundicola</i>	1				1	0.06	0.5
<i>Limnodrilus udekemianus</i>			1		1	0.06	0.5
<i>Limnodrilus</i> sp.	913	9	51	8	981	60.44	27.5
<i>Lumbriculidae</i> spp.	1				1	0.06	0.5
Arthropoda							
Amphipoda							
<i>Gammarus</i> sp.	6		1	13	20	1.23	3.6
Insecta							
Ephemeroptera							
<i>Hexagenia bilineata</i>	1			1	2	0.12	0.9
<i>Hexagenia limbata</i>	4				4	0.25	1.4
<i>Pentagenia vittigera</i>	4	4	17	1	26	1.60	5.4
<i>Stenonema integrum</i>			1		1	0.06	0.5
<i>Tortopus incertus</i>	3		136	122	261	16.08	8.0
Odonata							
<i>Gomphus</i> sp.	2		1		3	0.18	1.4
Hemiptera							
<i>Mesovelia</i> sp.	1				1	0.06	0.5
<i>Corixidae</i> sp.	1				1	0.06	0.5
Trichoptera							
<i>Hydropsyche</i> sp.	3		3		6	0.37	2.7
<i>Lepidoptera</i> sp.				1	1	0.06	0.5
Coleoptera							
<i>Curculionidae</i> spp.			1		1	0.06	0.5
Diptera							
<i>Ablabesmyia</i> sp.	1			1	2	0.12	0.9
<i>Chaoborus punctipennis</i> -larvae	4		1	17	22	1.40	2.7
<i>Chironomus</i> sp.	1				1	0.06	0.5
<i>Ceolotanypus scapularis</i>	2		3		5	0.31	2.3
<i>Cryptochironomus flavus</i>	6		11		17	1.05	2.7
<i>Glyptotendipes meridionalis</i>	1				1	0.06	0.5
<i>Palposvia</i> sp.		1	1		2	0.12	0.9
<i>Polypedilum</i> sp.				2	2	0.12	0.9
<i>Procladius subletti</i>	2		1		3	0.18	0.9
<i>Rheotanytarsus</i> sp.		1			1	0.06	0.5
<i>Xenochironomus festivus</i>				1	1	0.06	0.5
<i>Chironomidae</i> spp.	1				1	0.06	0.5
Mollusca							
Pelecypoda							
<i>Corbicula fluminea</i>	3	3	17	2	25	1.54	10
<i>Sphaerium transversum</i>	1		1		2	0.12	0.9
Total density	1165	26	260	172	1623	100	
Average total density/0.05 m ²	16.64	0.86	3.82	3.17	7.40		
Average number of taxa/0.05 m ²	1.47	0.57	1.01	0.57	0.90		

Table 3
Dike Field Habitat--Summary of Water Quality Data for June 1978 Sampling Effort

Dike Field	Depth	Temperature		Dissolved		pH		Conductivity	
		Surface	Bottom	Oxygen, mg/l	Surface	Bottom	Surface	Bottom	µmhos
Lower Cracraft	Max	29.0	26.5	8.7	6.8	8.6	8.2	530	525
	Min	21.5	25.5	--	6.2	7.9	7.3	400	400
	—X	26.3	25.7	--	6.5	8.0	8.1	463	413
Island 86	Max	28.5	--	9.6	--	7.6	--	530	--
	Min	26.0	--	5.2	--	7.5	--	510	--
	—X	27.5	--	7.5	--	7.5	--	528	--
Leota	Max	31.0	31.0	11.0	13.6	8.3	8.2	500	500
	Min	25.7	25.5	6.1	5.5	7.5	7.5	400	400
	—X	26.7	27.0	7.2	7.8	7.9	7.8	452	458
Seven Oaks	Max	30.5	--	9.7	--	7.9	--	570	--
	Min	25.6	--	6.5	--	7.5	--	420	--
	—X	27.8	--	7.5	--	7.6	--	497	--

Table 4
Sample Variance Component Analysis for Estimates
of Total Density and Number of Taxa,
Dike Fields

<u>Sample Variance Component</u>	<u>Variance Estimate</u>	<u>Percent of Total Sample Variance</u>
<u>Total Density</u>		
Total sample variance	688.78	100.0
Among habitats	35.36	5.13
Among stations within habitats	467.54	67.88
Among replicates within stations and sites	185.88	26.99
<u>Number of Taxa</u>		
Total sample variance	1.86	100.0
Among habitats	0.14	7.53
Among stations within habitats	0.96	51.75
Among replicates within stations and sites	0.76	40.72

Table 5
Benthic Macroinvertebrates Obtained from 20 Individual
Stone Samples in June 1978, Seven Oaks Dike

<u>TAXON</u>	<u>Total Number Collected</u>	<u>Average No. Rock Sample</u>	<u>Total Percent Composition</u>
Insecta			
Trichoptera			
<u>Hydropsyche</u> spp.	9,267	463.4	86.4
<u>Potamyia</u> <u>flava</u>	182	9.1	1.7
<u>Cyrnellus</u> sp.	1	0.05	>0.1
Lepidoptera			
<u>Lepidoptera</u> sp.	1	0.05	>0.1
Ephemeroptera			
<u>Stenonema</u> <u>integrum</u>	69	3.5	0.6
<u>Baetis</u> sp.	107	5.4	1.0
<u>Heptagenia</u> <u>marginalis</u>	54	2.7	0.5
<u>Isonychia</u> sp.	8	0.4	>0.1
Odonata			
<u>Didymops</u> <u>transversa</u>	1	0.05	>0.1
<u>Argia</u> sp.	1	0.05	>0.1
Diptera			
<u>Rheotanytarsus</u> sp.	542	27.1	5.1
<u>Polypedilum</u> sp.	480	24.0	4.2
<u>Ablabesmyia</u> sp.	3	0.2	>0.1
Plecoptera			
<u>Neoperla</u> sp.	1	0.05	>0.1
Collembola			
<u>Isotomurus</u> sp.	3	0.2	>0.1
Mollusca			
Gastropoda			
<u>Physa</u> <u>hawnii</u>	1	0.05	>0.1
<u>Planorbula</u> sp.	1	0.05	>0.1
Hirudinea			
	4	0.03	>0.1
Totals	10,726	536.38	--

Table 6
Aquatic Macroinvertebrate Taxa Collected from Rock
Dike Structures Within the Lower Mississippi
River Study Area, June 1978

<u>INSECTA</u>	<u>MOLLUSCA</u>
<u>Collembola</u>	<u>Gastropoda</u>
<u>Isotomurus</u> sp.	<u>Physa</u> <u>hawnii</u>
<u>Trichoptera</u>	<u>Planorbula</u> sp.
<u>Hydropsyche</u> spp.	<u>Pelecypoda</u>
<u>Potamyia</u> <u>flava</u>	<u>Corbicula</u> <u>fluminea</u>
<u>Cyrnellus</u> sp.	
<u>Orthotrichia</u> sp.	
<u>Ephemeroptera</u>	<u>CRUSTACEA</u>
<u>Baetis</u> sp.	<u>Isopoda</u>
<u>Isonychia</u> sp.	<u>Lirceus</u> sp.
<u>Heptagenia</u> sp.	<u>Amphipoda</u>
<u>Stenonema</u> <u>integrum</u>	<u>Gammarus</u> <u>fasciatus</u>
<u>Stenonema</u> <u>gildersleevei</u>	
<u>Diptera</u>	<u>Decapoda</u>
<u>Polypedilum</u> sp.	<u>Macrobrachium</u> <u>ohione</u>
<u>Rheotanytarsus</u> sp.	
<u>Ablabesmyia</u> sp.	
<u>Glyptotendipes</u> <u>meridionalis</u>	
<u>Dicrotendipes</u> sp.	
<u>Robackia</u> <u>claviger</u>	
<u>Lepidoptera</u>	
<u>Lepidopteran</u> sp.	
<u>Plecoptera</u>	
<u>Neoperla</u> sp.	
<u>Odonata</u>	
<u>Didymops</u> <u>transversa</u>	
<u>Argia</u> sp.	
<u>Ishnura</u> sp.	
<u>HIRUDINEA</u> Free-living leeches	

Table 7
Revetted Bank Habitat, Macroinvertebrate Data Summary
for June 1978 Sampling Effort

Taxon	Revetment			Total Abundance	Percent of Total Abundance	Frequency of Occurrence (Percent of Total Habitat Sample)
	Walnut Point	Worthington	Mayersville			
Annelida						
<i>Oligochaeta</i>						
<i>Branchiura sowerbyi</i>	1			1	0.79	1.1
<i>Limnodrilus cervix</i>	18			18	14.38	5.6
<i>Limnodrilus hoffmeisteri</i>	6			6	4.85	4.5
<i>Limnodrilus</i> spp.	73			73	57.20	5.6
Arthropoda						
Insecta						
<i>Ephemeroptera</i>						
<i>Hexagenia bilineata</i>	3	1		3	2.38	1.1
<i>Stenonema femoratum</i>				1	0.79	1.1
<i>Tortopus incertus</i>	2			2	1.58	2.2
<i>Trichoptera</i>						
<i>Cyriellus</i> sp.			1			
<i>Hydropsyche</i> spp.	2		1	1	0.79	1.1
<i>Diptera</i>				3	2.38	3.4
<i>Chaborus punctipennis</i>	8			1		
<i>Cryptochironomus</i> sp.	1			9	7.74	3.4
<i>Parachironomus</i> sp.	1			1	0.79	1.1
<i>Procladius subletti</i>	1			1	0.79	1.1
<i>Pseudochironomus richardsoni</i>	1			1	0.79	1.1
<i>Robackia claviger</i>	3			3	2.38	1.1
<i>Mollusca</i>				1	0.79	1.1
<i>Pelecypoda</i>						
<i>Corbicula fluminea</i>	1	1		2	1.58	1.1
Total Density	118	5	1	1	126	100
Average Total Density/0.05 m²	1.84	0.71	0.17	0.25	0.125	
Average Number of Taxa/0.05 m²	0.42	0.43	0.17	0.25	0.125	

Table 8
Natural Bank Habitat, Macroinvertebrate Data Summary
for June 1978 Field Sampling Effort

Taxon	Natural Bank	Total	Percent of Total Abundance	Frequency of Occurrence (Percent of Total Habitat Sample)				
	Anconia	Lakeport	Island 88	Mayersville	Seven Oaks	Abundance		
Annelida								
Oligochaeta				4		4	0.40	3.70
<i>Limnodrilus udekemianus</i>			2		1	3	0.30	2.80
<i>Limnodrilus</i> sp.	6	5				11	1.08	6.90
Arthropoda								
Amphipoda								
<i>Corophium</i> sp.				6		8	0.79	2.80
<i>Gammarus</i> sp.	1	1	5	4		11	1.08	7.80
Insecta								
Ephemeroptera								
<i>Baetis</i> sp.		6		1		7	0.69	1.80
<i>Hexagenia limbata</i>	1		3			4	0.40	1.00
<i>Isonychia</i> sp.			1			1	0.09	0.93
<i>Pentagenia vittigera</i>	7	5	28	42		82	8.17	22.30
<i>Stenonema integrum</i>	1			1		2	0.20	2.20
<i>Stenonema minnetonka</i>			1			1	0.09	0.93
<i>Stenonema tripunctatum</i>				1		1	0.09	0.93
<i>Stenonema</i> sp.			1			1	0.09	0.93
<i>Tortopus incertus</i>	56	38	42	187		323	32.08	43.10
<i>Leptophlebiidae</i> sp.			1			1	0.09	0.93
Odonata								
<i>Gomphus</i> sp.				1		1	0.09	0.93
Trichoptera								
<i>Cyrmelius</i> sp.				3		3	0.30	0.93
<i>Hydropsyche</i> spp.	6	143	5	279		433	42.8	15.40
<i>Polycentropus</i> sp.				1		1	0.09	0.93
<i>Potamia flava</i>	1	2	4	56		63	6.2	6.80
<i>Hydropsychidae</i>					2		0.20	1.80
Diptera								
<i>Chaoborus punctipennis</i> -larvae			4			4	0.40	0.93
<i>Chaoborus punctipennis</i> -pupae	1						0.09	0.93
<i>Chironomus plumosus</i>				1		1	0.09	0.93
<i>Chironomus</i> sp.			1			1	0.09	0.93
<i>Cryptochironomus flavus</i>			1			1	0.09	0.93
<i>Palpomyia</i> sp.		4				4	0.40	1.80
<i>Polydendrium</i> sp.	5	3		2		10	0.98	4.20
<i>Prociadium subtletti</i>		1				1	0.09	0.93
<i>Pseudochironomus richardsoni</i>				1		1	0.09	0.93
<i>Xenochironomus festivus</i>				11		11	1.08	2.80
Mollusca								
Pelecypoda								
<i>Cardium</i> sp.	2			11		13	1.19	1.10
Total density								
Average total density/0.05 m ²	87	214	93	616	1	1011	100%	
Average number of taxa/0.05 m ²	4.83	5.09	5.17	26.78	0.17	9.4		
	1.50	0.88	1.72	2.91	0.17	1.4		

Table 9
Natural Bank Habitat--Summary of Water Quality Data for June 1978 Sampling Effort

Natural Bank	Depth	Temperature		Dissolved Oxygen, mg/l		pH		Conductivity μmhos	
		Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
Anconia	Max	24.6	--	6.2	--	7.7	--	370	--
	Min	24.5	--	6.1	--	7.7	--	350	--
	\bar{X}	24.6	--	6.2	--	7.7	--	360	--
Lakeport	Max	27.2	26.1	6.5	6.4	7.9	7.8	448	429
	Min	26.0	26.1	6.2	6.4	7.8	7.8	255	429
	\bar{X}	26.3	26.1	6.4	6.4	7.8	7.8	411.5	429
Island 88	Max	27.0	26.6	7.0	6.8	7.9	7.9	407	405
	Min	26.1	26.1	6.7	6.7	7.8	7.8	402	402
	\bar{X}	26.6	26.4	6.8	6.8	7.9	7.9	405	403
Mayersville	Max	28.2	--	7.7	--	8.0	--	395	--
	Min	27.4	--	6.3	--	7.8	--	302	--
	\bar{X}	27.7	--	6.7	--	7.9	--	361	--

Table 10
Variance Component Analysis for Estimates of Total Density
and Number of Taxa, Natural Banks

<u>Sample Variance Component</u>	<u>Variance Estimate</u>	<u>Percent of Total Sample Variance</u>
<u>Total Density</u>		
Total sample variance	1438.43	100.0
Among habitats	1.62	0.11
Among stations within habitats	157.16	10.93
Among replicates within stations and sites	1279.65	88.96
<u>Number of Taxa</u>		
Total sample variance	4.17	100.0
Among habitats	0.39	9.27
Among stations within habitats	1.43	34.22
Among replicates within stations and sites	2.36	56.51

Table 11
Abandoned Channel Habitat--Summary of Water Quality for June 1978 Sampling Effort

Location	Depth	Temperature °C		Dissolved Oxygen, mg/l		pH		Conductivity μmhos	
		Surface	Bottom	Surface	Bottom	Surface	Bottom	Surface	Bottom
Matthews Bend	Max	30.5	28.2	11.2	6.4	8.7	8.2	--	--
	Min	25.8	21.5	4.7	0.0	7.8	7.5	--	--
	̄X	28.5	25.9	8.3	1.1	8.4	7.6	--	--
Carolina Chute	Max	34.0	--	11.0	--	7.4	--	620	--
	Min	31.5	--	8.3	--	7.0	--	570	--
	̄X	32.8	--	9.8	--	7.2	--	594	--
Lakeport	Max	32.5	--	9.5	--	8.5	--	350	--
	Min	30.0	--	7.5	--	8.0	--	350	--
	̄X	31.5	--	8.4	--	8.2	--	350	--
Moon Chute	Max	30.0	29.5	7.5	8.7	8.0	8.2	600	600
	Min	26.5	27.0	4.7	3.6	7.8	7.6	450	460
	̄X	28.8	28.8	6.1	6.9	7.9	8.0	535	527
Lake Lee	Max	29.5	25.1	14.0	5.9	9.2	8.0	400	540
	Min	25.3	16.0	9.6	0.1	6.0	7.2	300	360
	̄X	27.6	20.7	11.6	1.8	8.6	7.4	363	427

Table 12
Abandoned Channel Habitat--Macroinvertebrate Data Summary
for June 1978 Sampling Effort

Taxon	Abandoned Channel					Total Abundance	Percent of Total Abundance	Frequency of Occurrence (Percent of Total Habitat Sample)
	Matthews Bend	Carolina Chute	Lake Port	Moon Chute	Lake Lee			
Nematoda			1			1	0.01	1
Annelida								
Oligochaeta								
<i>Branchiura sowerbyi</i>	6			4		4	0.06	1
<i>Ilyodrilus</i> sp.	1			1	20	22	0.16	7
<i>Limnodrilus cervix</i>	22	6	4	26	123	181	2.58	35
<i>Limnodrilus claparedianus</i>					20	1	0.01	1
<i>Limnodrilus claparedianus/cervix</i>	1				1	21	0.30	5
<i>Limnodrilus hoffmeisteri</i>	65	40	8	92	92	297	4.23	49
<i>Limnodrilus</i> spp.	239	53	68	385	527	1272	18.14	58.0
<i>Lumbriculidae</i> spp.					2	2	0.03	1
Hirudinea			1	5	1	7	0.20	4
Arthropoda								
Mysidacea								
<i>Taphromysis lousianeae</i>				1	2	3	0.04	2
Isopoda								
<i>Astellus</i> sp.						1	0.01	1
<i>Lirceus</i> sp.	1	3				4	0.06	2
Insecta								
Ephemeroptera								
<i>Caenis</i> sp.				1		1	0.01	2
<i>Hexagenia bilineata</i>	1			1		1	0.01	1
<i>Hexagenia limbata</i>	3				10	13	0.19	5
<i>Stenonema integrum</i>				1		1	0.01	1
Hemiptera								
<i>Graptocorixa</i>	7					7	0.10	3
Corixidae	7				1	1	0.01	1
Trichoptera								
<i>Potamya flava</i>					1	1	0.01	1
Lepidoptera								
Lepidoptera sp.	1					1	0.01	1
<i>Arzama</i> sp.	1					1	0.01	1
Diptera								
<i>Chaoborus punctipennis-larvae</i>	1062	705	226	346	183	2219	31.22	93.0
<i>Chaoborus punctipennis-pupae</i>	98	29	3		60	195	2.78	45
<i>Chironomus plumosus</i>	1		1	1	32	35	0.50	13
<i>Chironomus</i> spp.		2	27	4	106	139	1.98	28
<i>Coelotanypus acapularis</i>	6		49	43	312	713	10.77	58.0
<i>Cryptochironomus falvus</i>				1		1	0.01	1
<i>Einfeldia natchitochae</i>				5		5	0.07	2
<i>Glyptotendipes meridionalis</i>	1	2				3	0.04	2
<i>Kiefferulus</i> sp.		4				4	0.06	2
<i>Lauterborniella</i> sp.	1					1	0.01	1
<i>Palpomyia</i> sp.	4					13	0.19	17
<i>Parachironomus</i> sp.		1				1	0.01	1
<i>Procladius subletti</i>	10		1	5	4	20	0.29	9
<i>Stratiomyia</i> sp.		1				1	0.01	1
<i>Tanypus stellatus</i>	2		851	82	1	936	13.34	29
<i>Chironomidae</i> spp.					2	2	0.03	1
Mollusca								
Pelecypoda								
<i>Sphaerium transversum</i>	188		68	15	540	811	11.56	53.0
Gastropoda								
<i>Campeloma</i> sp.					37	37	0.53	4
<i>Phasianella hawaii</i>	1		1	2		4	0.06	4
<i>Viviparus</i> sp.					3	3	0.04	2
Total Density	2104	1015	1319	857	1709	7004	100	
Average Total Density/0.05 m ²	70.07	56.38	82.81	47.61	94.94	70.04		
Average Number of Taxa/0.050m ²	6.87	6.06	5.56	2.94	4.44	5.20		

Table 13

Sample Variance Component Analysis for Estimate of Total
Density and Number of Taxa, Abandoned Channel Habitat

<u>Sample Variance Component</u>	<u>Total Density</u>			<u>Number of Taxa</u>	
	<u>Variance Estimate</u>	<u>Percent of Total Sample Variance</u>	<u>Variance Estimate</u>	<u>Percent of Total Sample Variance</u>	
Total sample variance	2628.30	100.0	5.75	100.0	
Among habitats	151.26	5.75	2.79	39.66	
Among stations within habitats	1092.91	41.58	0.97	16.78	
Among replicates within stations and sites	1384.13	52.66	2.51	43.56	

Table 14
Other Habitats--Summary of Water Quality Data for June 1978 Sampling Effect

Location	Depth	Temperature			Surface		Conductivity μmhos
		°C	Dissolved Oxygen, mg/l	pH			
Permanent Channel, American Cutoff	Max	27.3	6.4	7.9			368
	Min	27.1	6.2	7.8			305
	X	27.2	6.3	7.8			350
Temporary Channel, Kentucky Bend	Max	27.5	7.3	7.0			530
	Min	27.5	6.1	7.0			530
	X	27.5	7.0	7.0			530
Main Channel	Max	27.7	7.1	8.0			468
	Min	25.9	6.4	7.8			373
	X	26.7	6.6	7.9			428
Sandbar, Kentucky Bend	Max	28.1	6.8	7.9			465
	Min	25.5	6.2	7.8			402
	X	26.4	6.4	7.8			451

Table 15
Other Habitats--Macroinvertebrate Data Summary
for June 1978 Sampling Effort

Taxon	Permanent Channel American Cutoff	Temporary Channel Kentucky Bend	Main Channel	Sandbar Kentucky Bend	Frequency of Occurrence (Percent of Total Habitat Sample)	
					Total Abundance	Percent of Total Abundance
Annelida						
<i>Oligochaeta</i>						
<i>Limnodrilus</i> spp.		1	4	2	7	10.03
Arthropoda						
Amphipoda						
<i>Gammarus</i> sp.		1			1	1.33
Insecta						
Ephemeroptera						
<i>Hexagenia limbata</i>		10	1	1	12	17.00
<i>Pentagenia vittigera</i>		8	1	1	9	12.00
<i>Tortopus incertus</i>	1	6	1	1	9	12.00
<i>Baetis</i> sp.			1		1	1.33
Trichoptera						
<i>Hydropsyche</i> spp.	1	2			3	4.00
<i>Potamyia</i> sp.		1			1	1.33
Diptera						
<i>Chaoborus punctipennis</i>	3			1	4	5.33
<i>Chernovskia orbiculus</i>			1		1	1.33
<i>Coelotanypus scapularis</i>	1				1	1.33
<i>Procladius subletti</i>	2				2	1.33
<i>Robackia claviger</i>	1				1	1.33
Chironomidae	1				1	1.33
Mollusca						
Pelecyopoda						
<i>Corbicula fluminea</i> ^a	1	11	1	2	15	21.00
<i>Sphaerium transversum</i>		3		4	7	9.33
Total Density	3	51	12	9	75	100
Average Total Density/0.05 m²	0.25	2.13	1.50	0.50		
Average Number of Taxa/0.05 m²	0.25	1.04	1.00	0.50		

Table 16
Summary of Benthic Macroinvertebrate Data Collected from the
Nine Aquatic Habitats, June 1978

Habitat	Total Organisms Collected	Avg Density per Sample*	Total Distinct Taxa Collected	Avg Number of Taxa/Sample	Habitat Sampler Type
Dike Fields	1,623	7.4	32	0.9	Ponar Grab; Shipek Grab
Dike Structures	10,726	536.4	28	7.3	Individual Stones by Hand
Revetted Banks	126	0.6	15	0.3	Shipek Grab
Natural Banks	1,011	9.4	26	1.4	Shipek Grab
Abandoned Channels	7,004	70.04	39	5.2	Ponar Grab
Permanent Secondary Channel	3	0.3	3	0.3	Shipek Grab
Temporary Secondary Channel	51	2.1	14	1.0	Shipek Grab
Main Channel	9	0.5	6	0.5	Shipek Grab
Sandbars	12	1.5	7	1.0	Shipek Grab

* All grab sample data are standardized to number per 0.05 m².

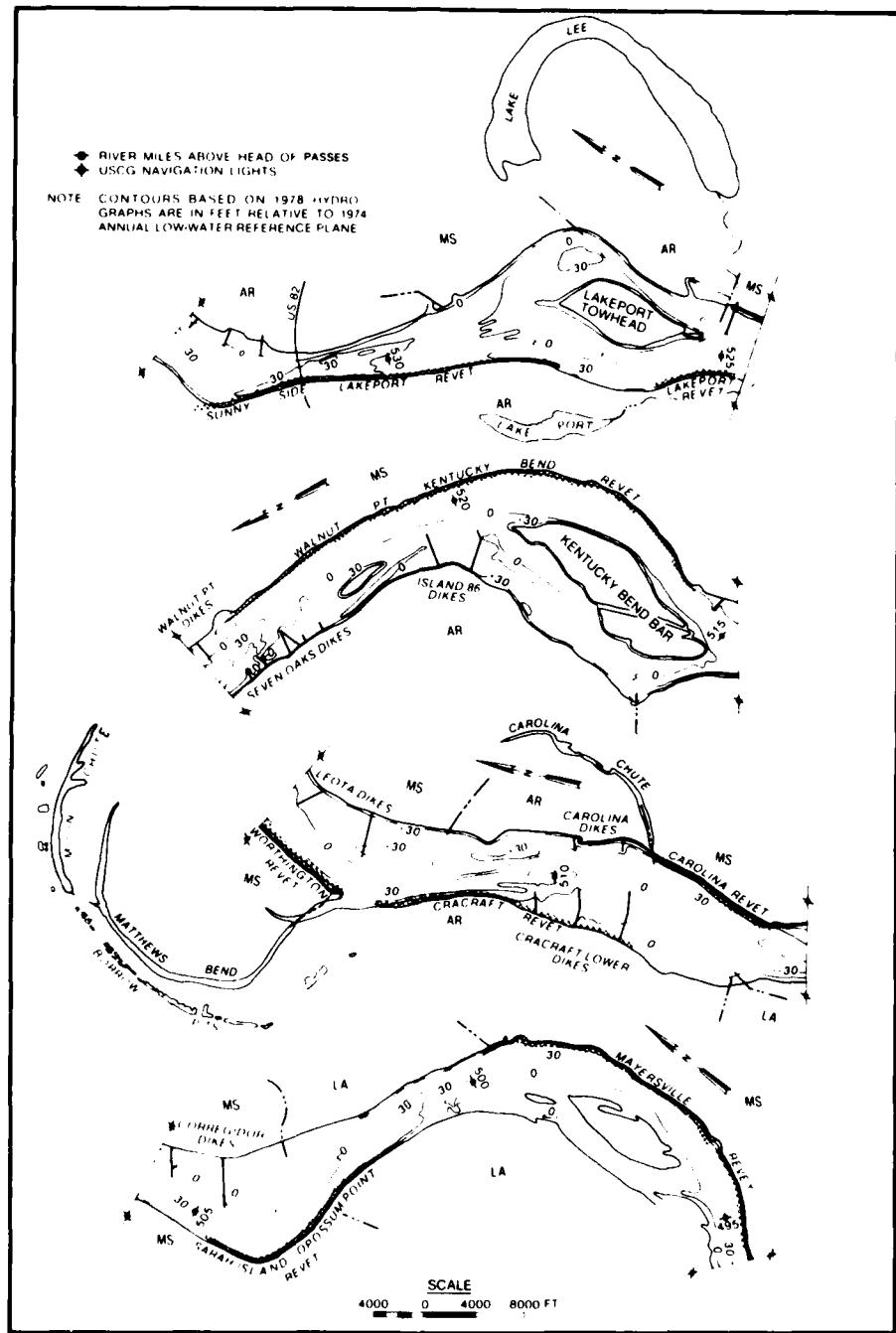


Figure 1. Maps of study area

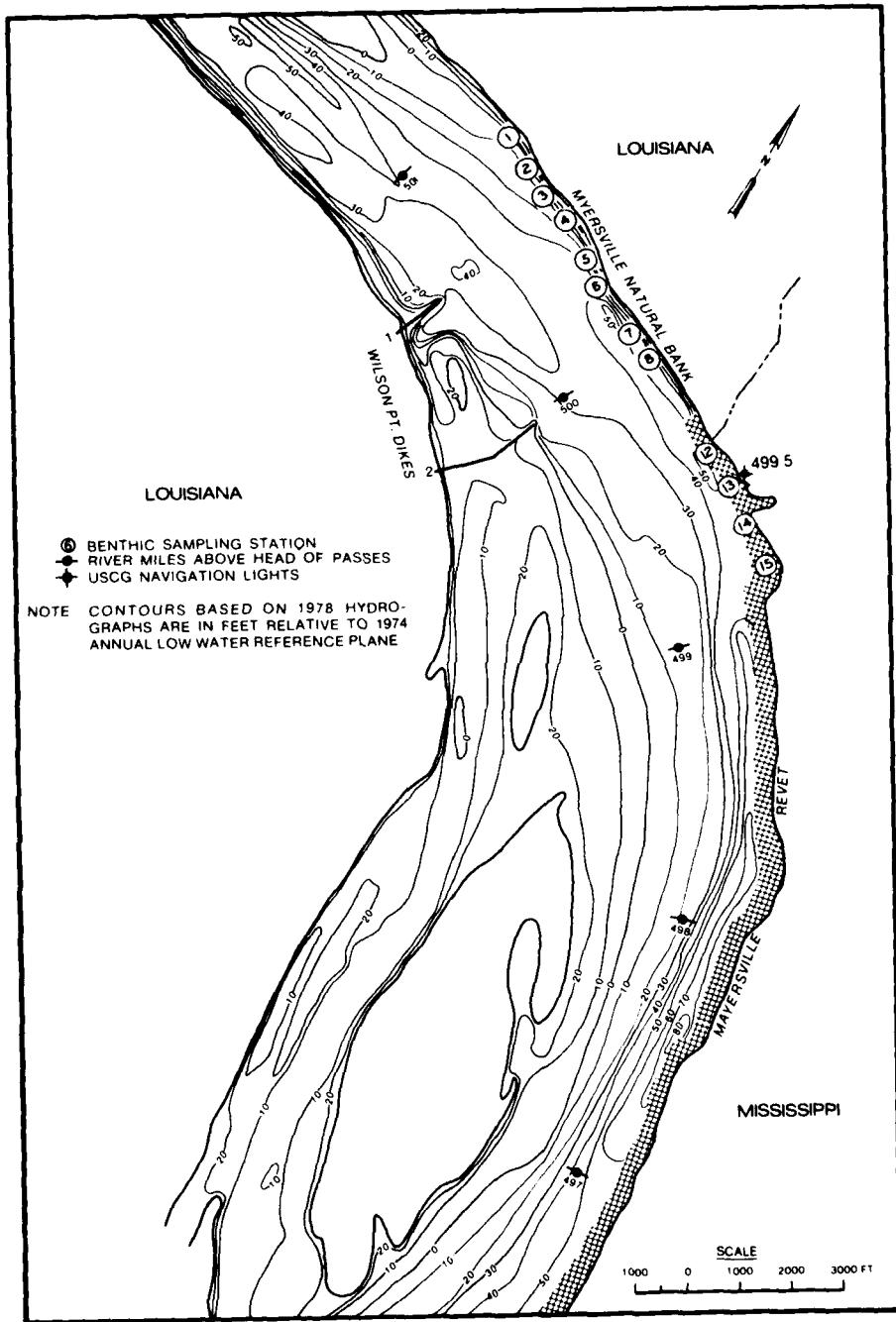


Figure 2. Sampling station at Mayersville Natural and Revetted Banks

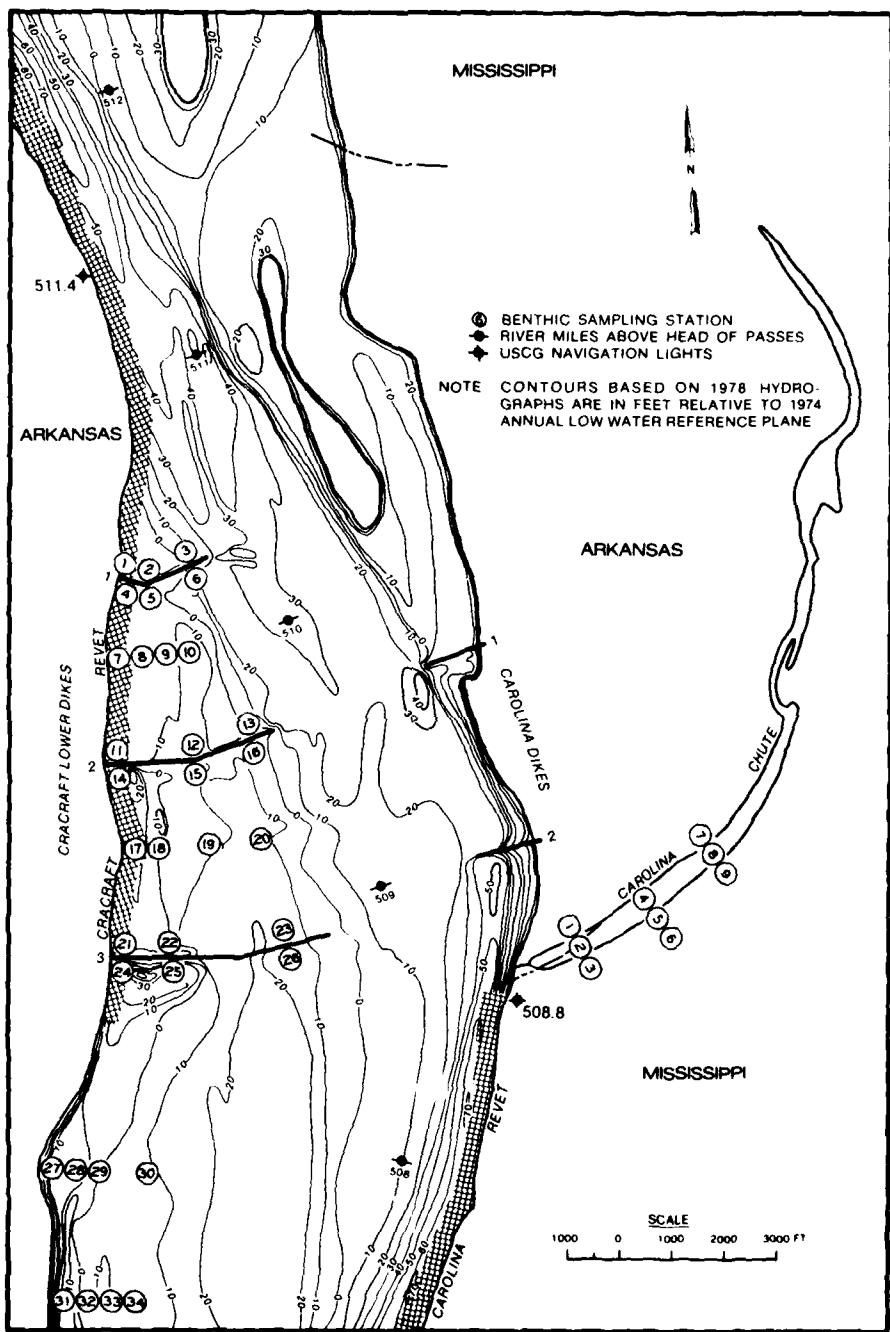


Figure 3. Sampling stations at Carolina Chute

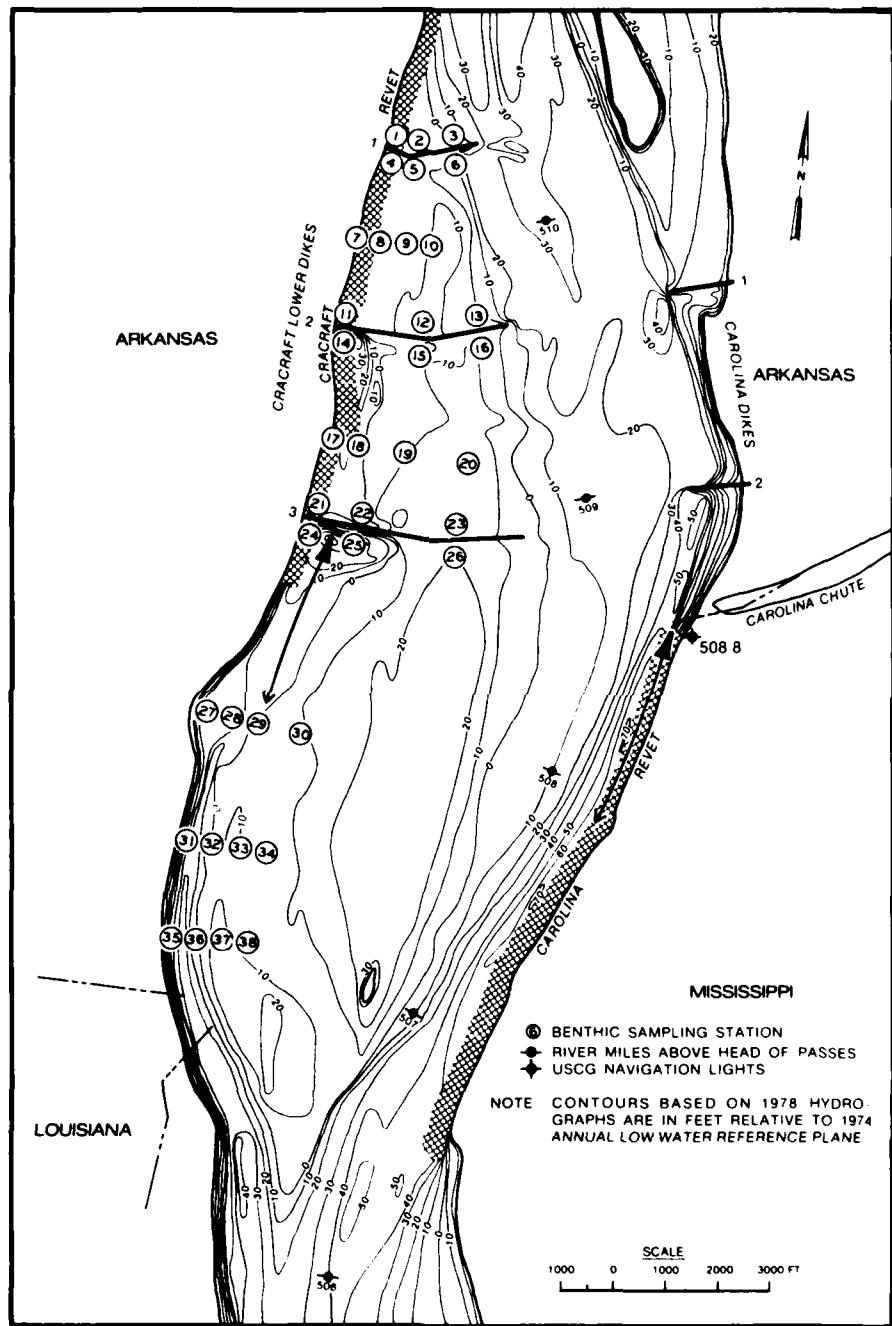


Figure 4. Sampling stations at Lower Cracraft Dike Field and Carolina Revetment

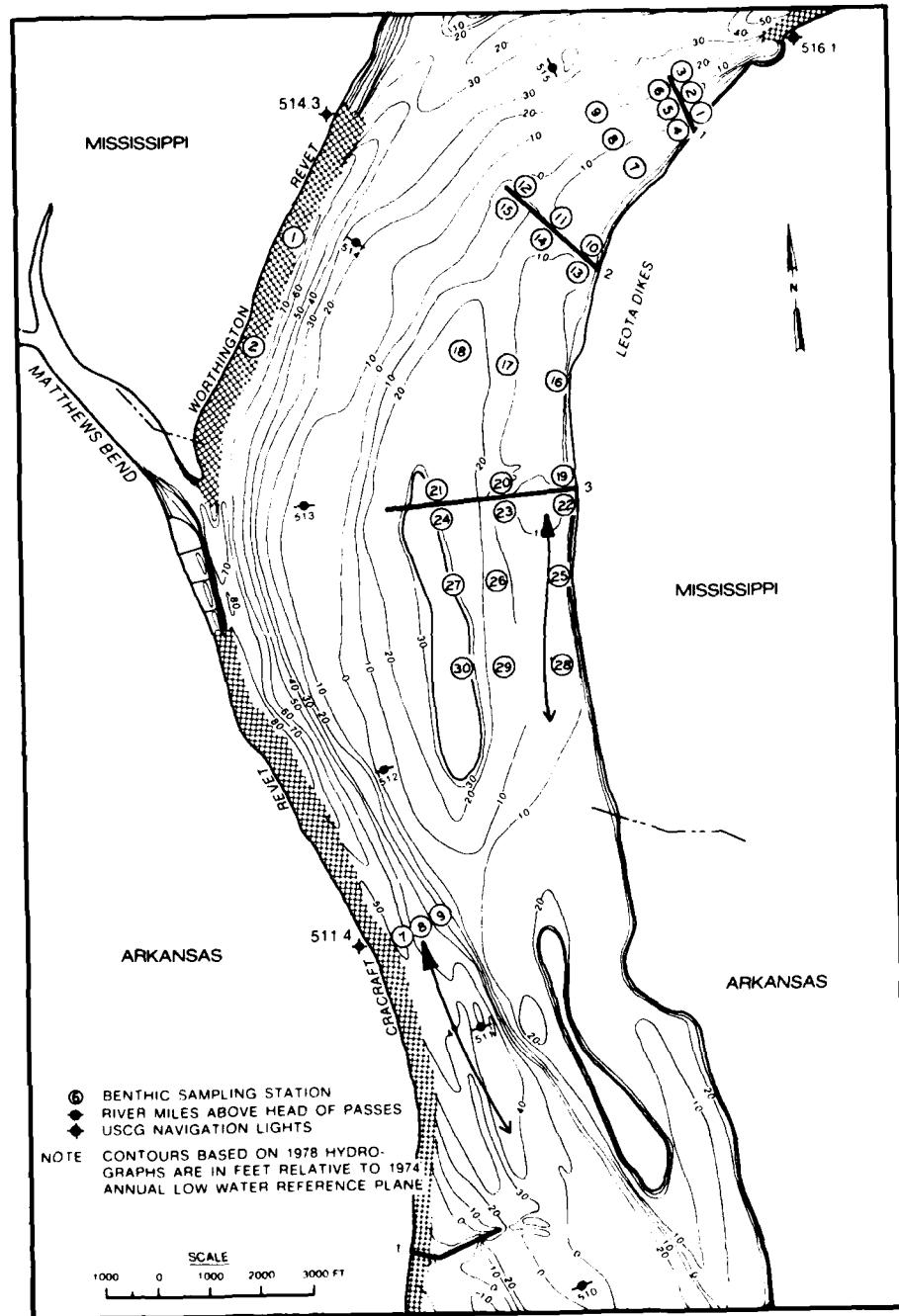


Figure 5. Sampling stations at Worthington Revetment, Leota Dike Field, and the Main Channel, river mile 511.4

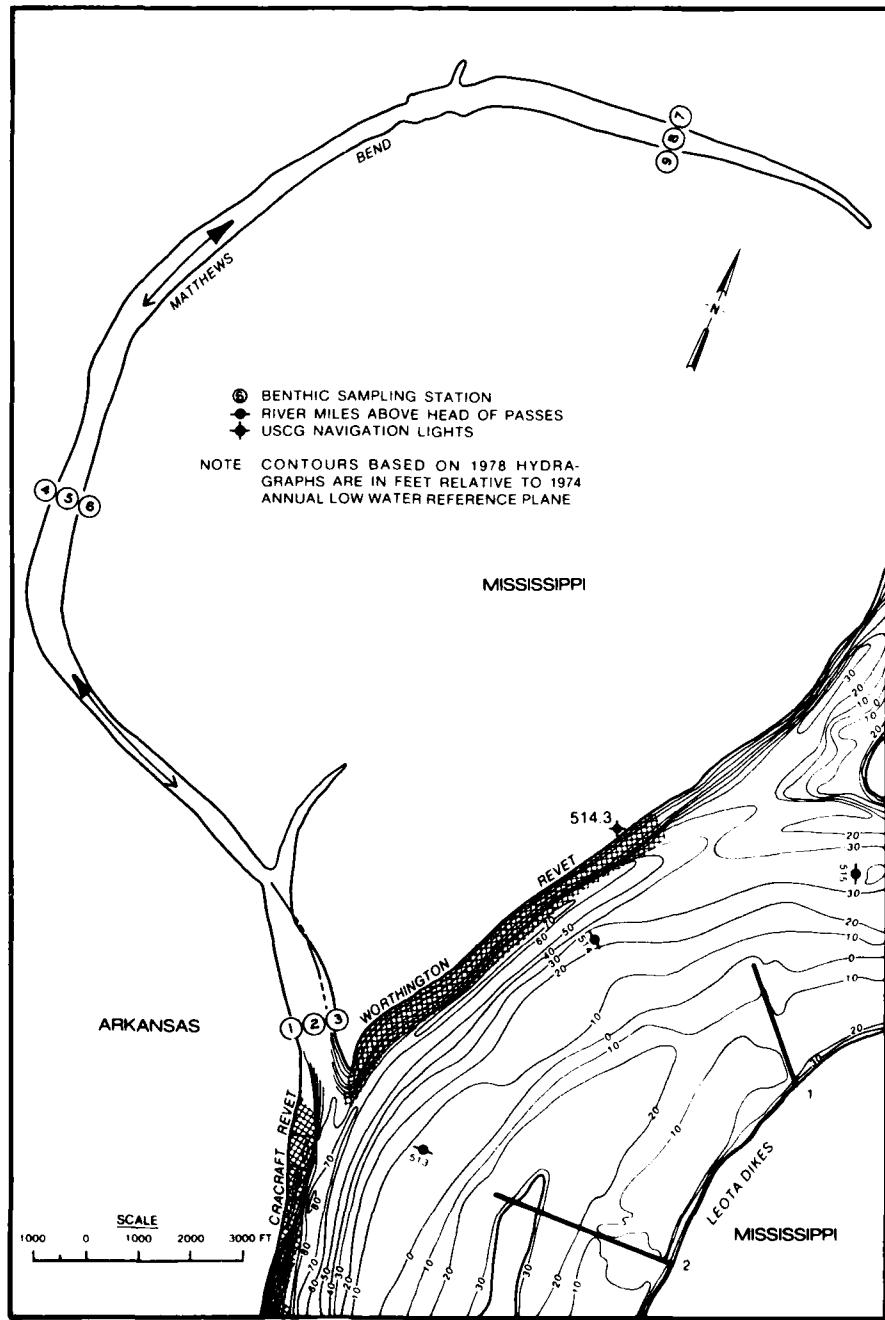


Figure 6. Sampling stations at Matthews Bend

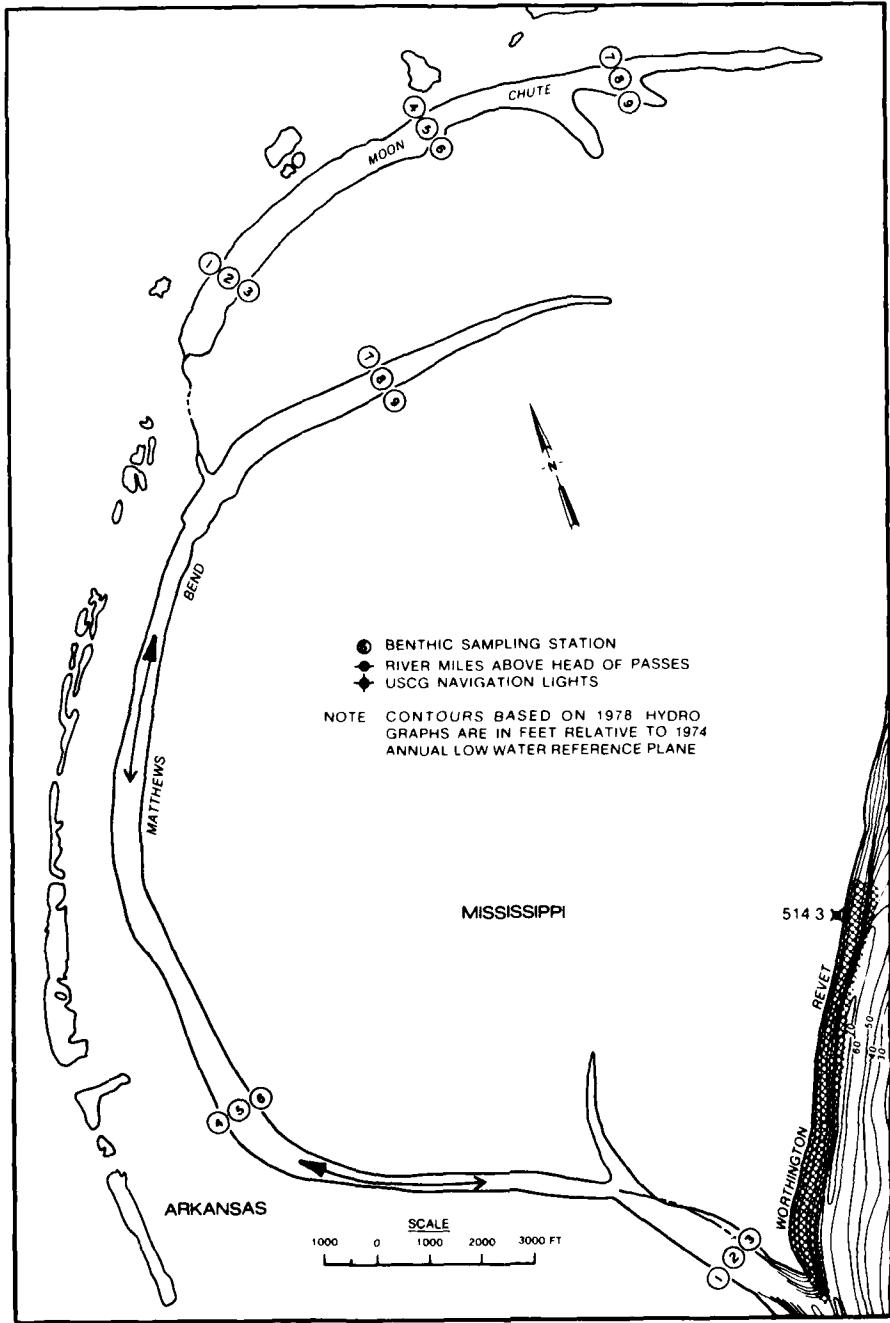


Figure 7. Sampling stations at Moon Chute

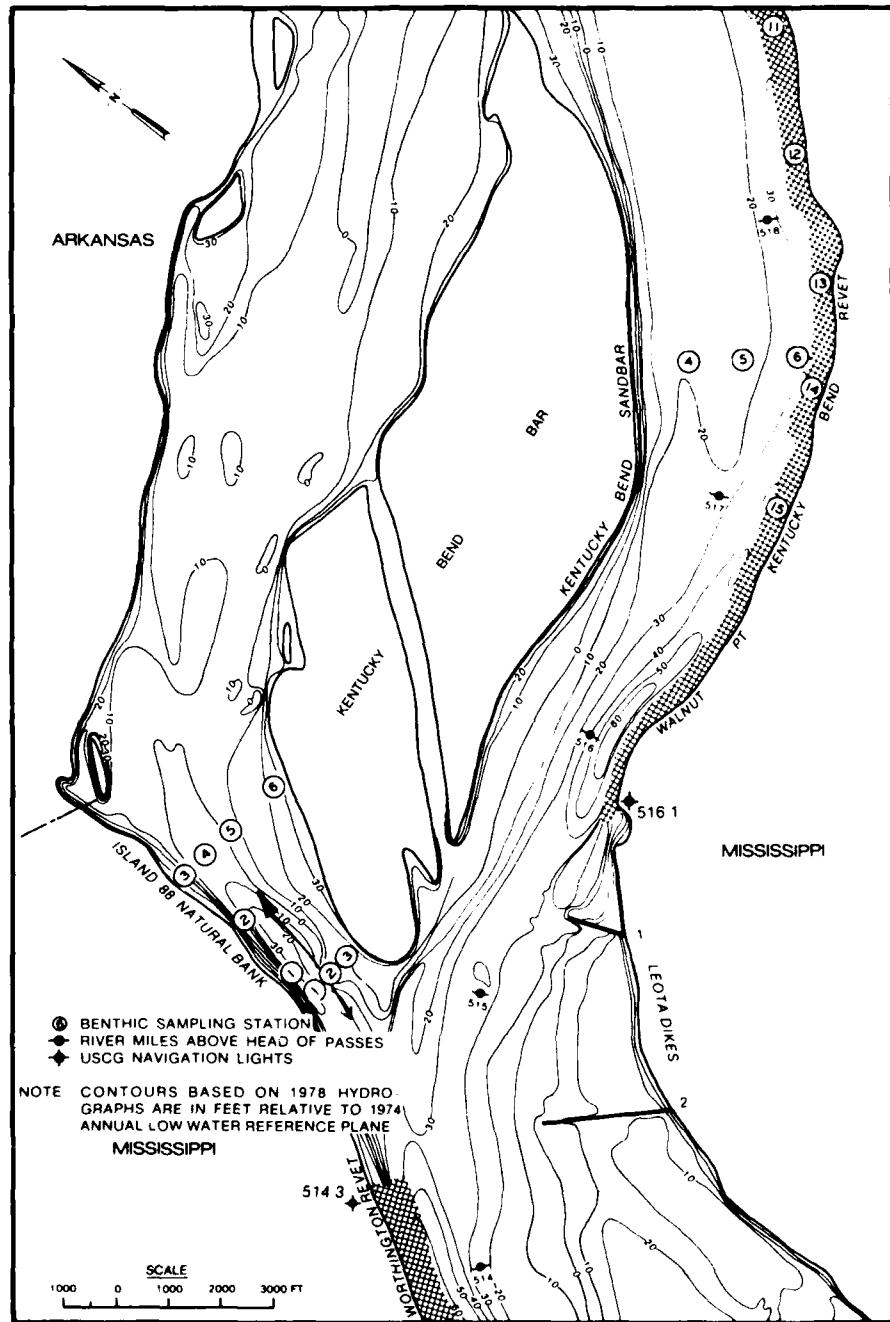


Figure 8. Sampling stations at Kentucky Bend Chute, Island 88 Natural Bank, Kentucky Bend Sandbar, Main Channel (river mile 519.1) and Walnut Point-Kentucky Bend Revetment

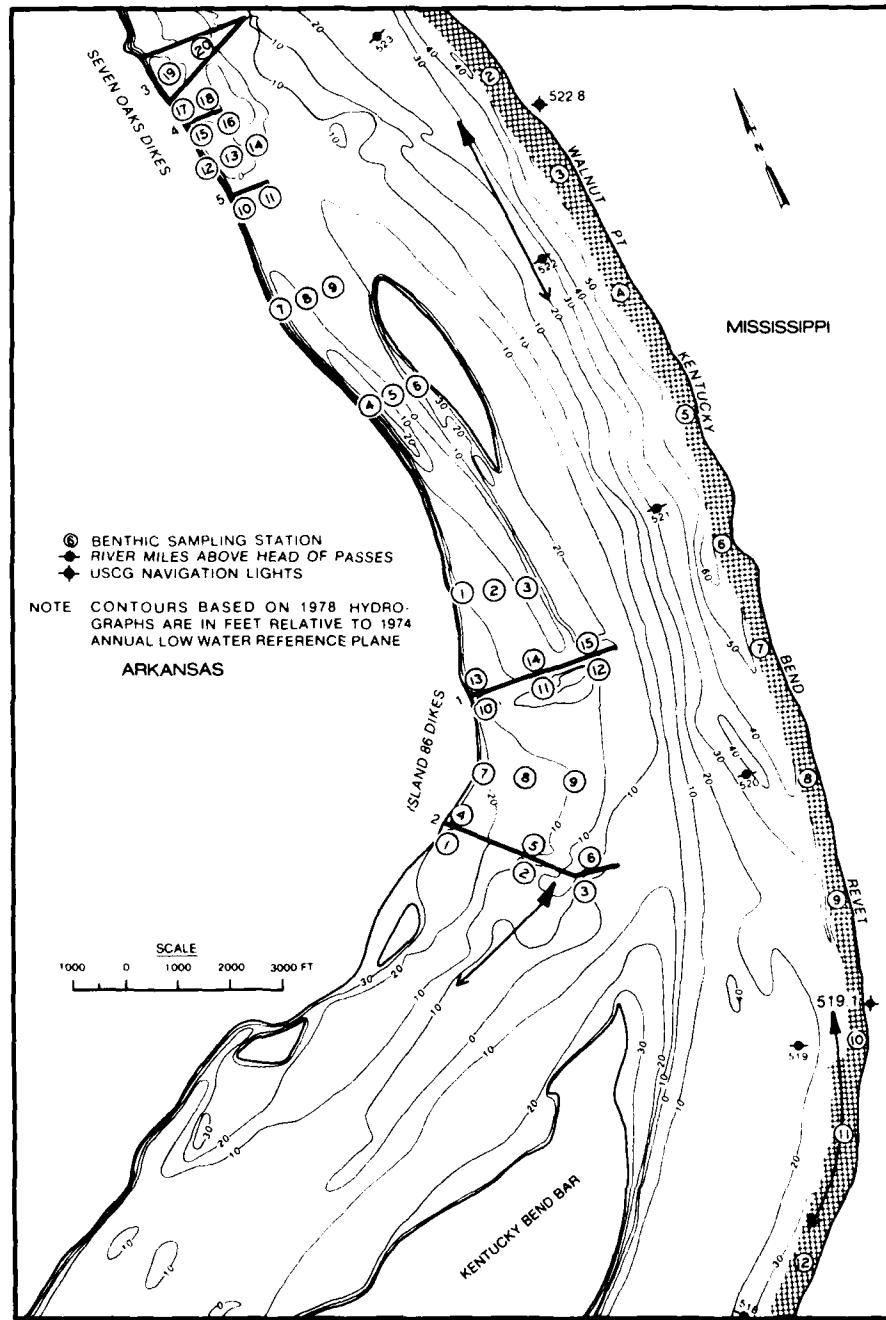


Figure 9. Sampling stations at Island 86 Dike Field and Walnut Point-Kentucky Bend Revetment

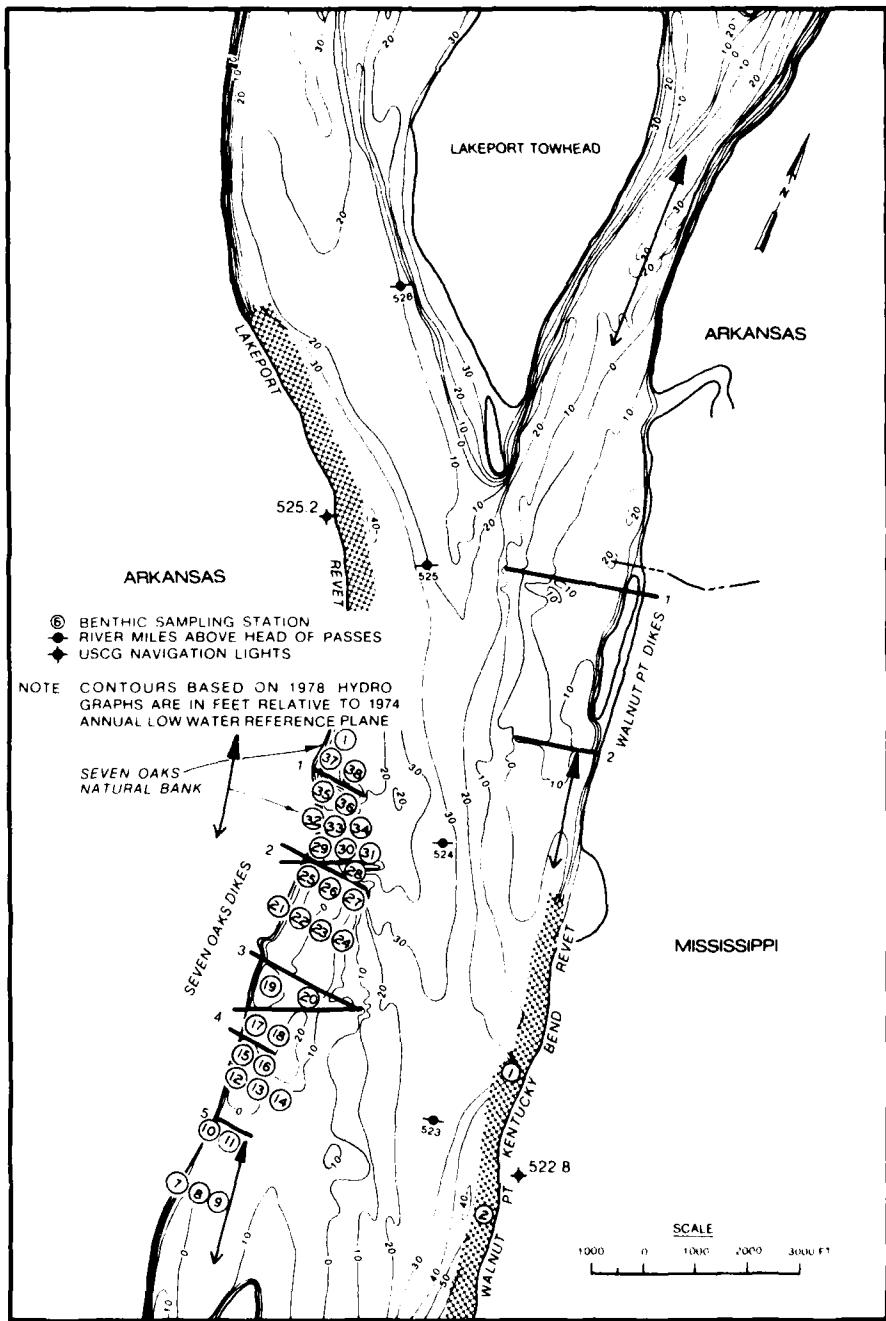


Figure 10. Sampling stations at Seven Oaks Natural Bank, and Seven Oaks Dike Field

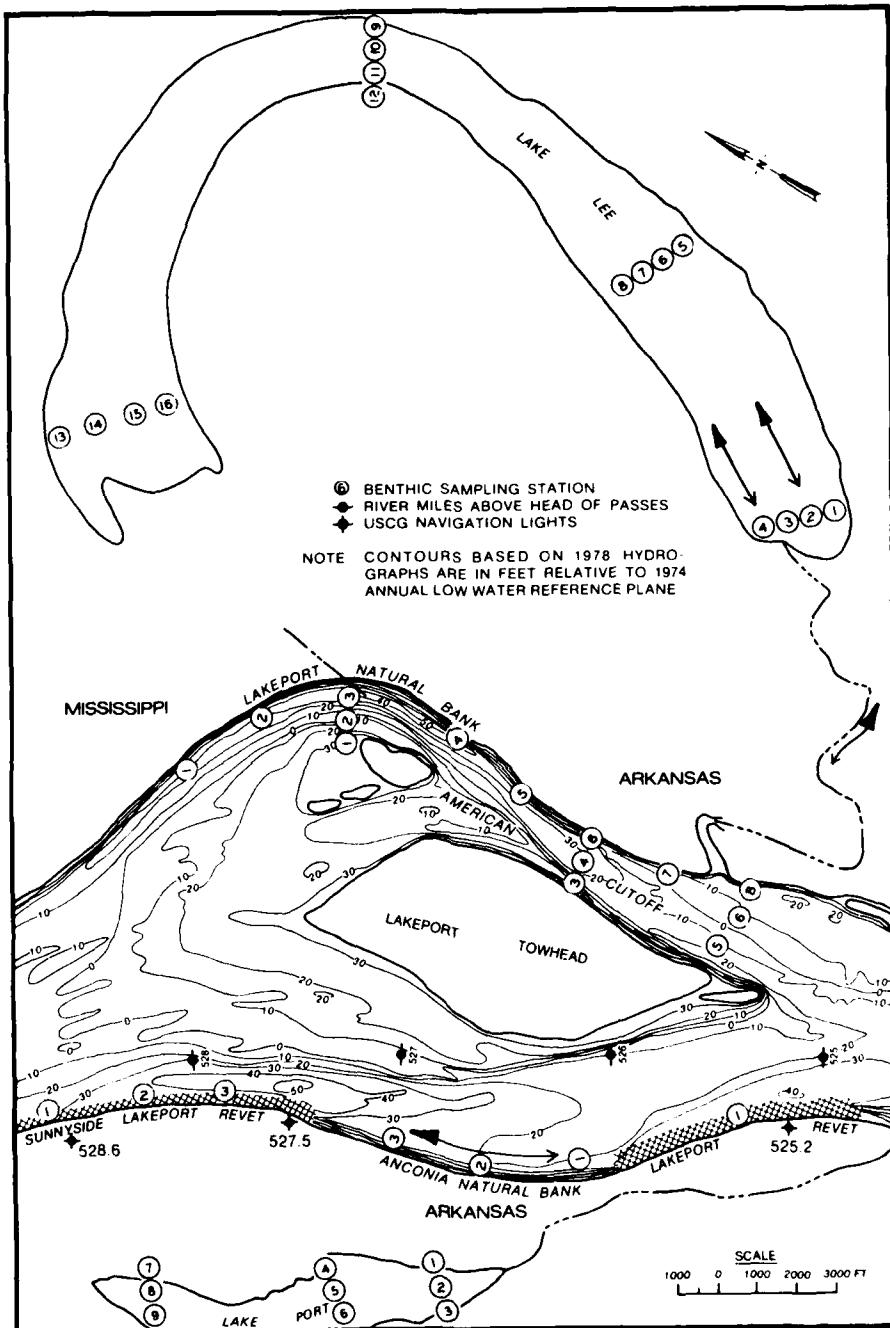


Figure 11. Sampling stations at Sunnyside and Lakeport Revetments, Anconia Natural Bank, Lakeport Natural Bank, and American Cutoff

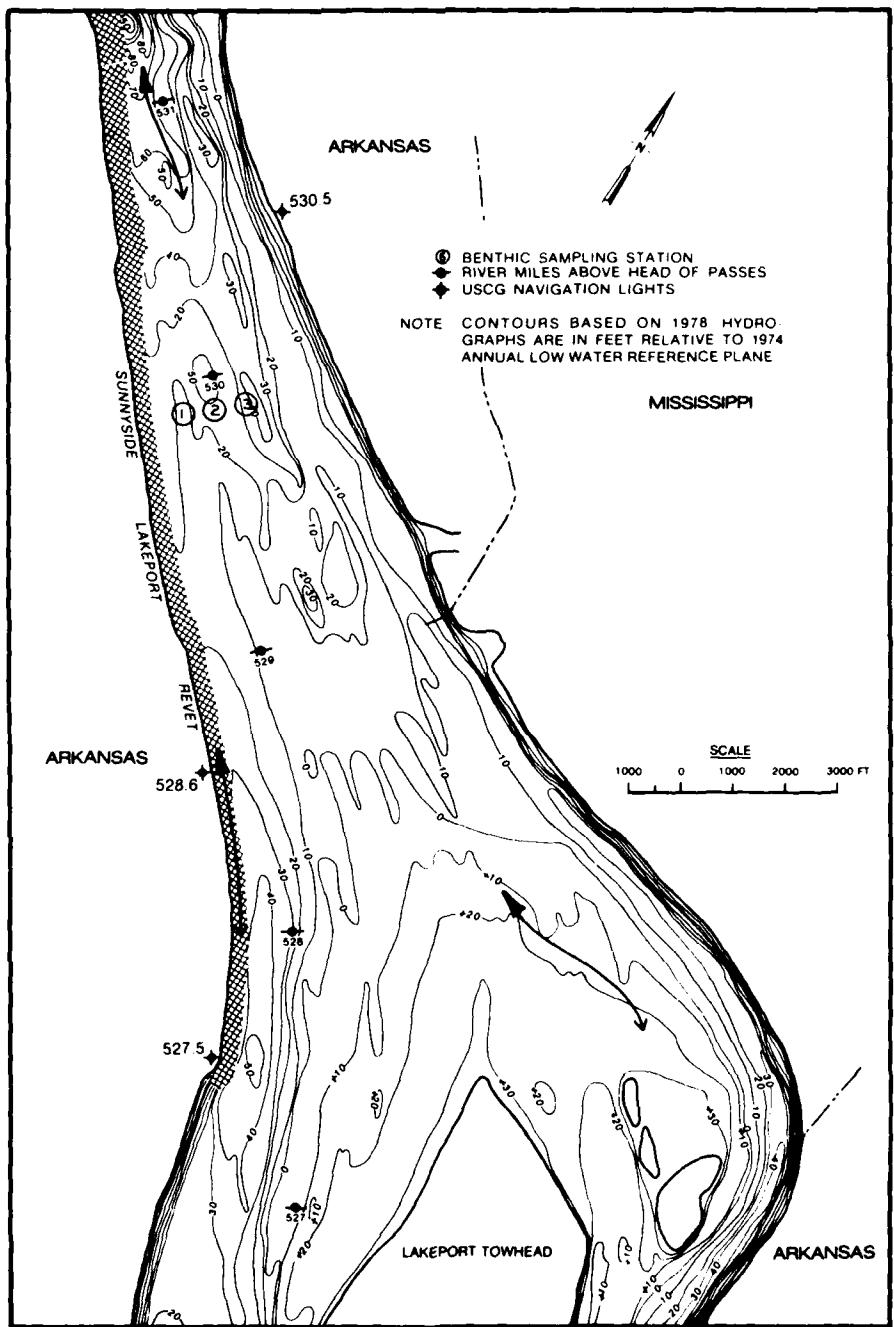


Figure 12. Sampling stations Main Channel

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Aquatic habitat studies on the Lower Mississippi River, river mile 480 to 530 : Report 3 : Benthic macro-invertebrate studies--pilot report / by David B. Mathis ... [et al.] (Environmental Laboratory, U.S. Army Engineer Waterways Experiment Station). -- Vicksburg, Miss. : The Station ; Springfield, Va. : available from NTIS, [1981].
53, [30] p. : ill. ; 27 cm. -- (Miscellaneous paper / U.S. Army Engineer Waterways Experiment Station ; E-80-1, Report 3)
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1. Aquatic animals. 2. Aquatic ecology. 3. Benthos.
4. Environmental protection. 5. Mississippi River.

Aquatic habitat studies on the Lower Mississippi : ... 1981.
(Card 2)

I. Mathis, David B. II. United States. Army. Corps of Engineers. Office of the Chief of Engineers.
III. Environmental and Water Quality Operational Studies. IV. U.S. Army Engineer Waterways Experiment Station. Environmental Laboratory. V. Series: Miscellaneous paper (U.S. Army Engineer Waterways Experiment Station) ; E-80-1, Report 3.
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